Thoracic and cardiovascular surgery in Japan in 2016 : Annual report by The Japanese Association for Thoracic Surgery

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ANNUAL REPORT

Thoracic and cardiovascular surgery in Japan in 2016

Annual report by The Japanese Association for Thoracic Surgery

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The Japanese Association for Thoracic Surgery has conducted annual surveys of thoracic surgery throughout Japan since 1986 to establish the statistics for the number of procedures by operative category. The results from our annual survey of thoracic surgery performed in 2016 are summarized.

As has been done so far, thoracic surgery was classified into three categories (cardiovascular, general thoracic, and esophageal surgery), and the patient data were examined and analyzed for each group. Access to the computerized data is offered to all members of this Association. We honor and value all members' continued professional support and contributions (Tables 1, 2).

The incidence of hospital mortality was added to the survey to clarify the situation nationwide, which has contributed to Japanese surgeons understanding the present status of thoracic surgery in Japan and to make progress to improve operative results by comparing their work with that of others. The Association was able to gain a better understanding of present problems, as well as future prospects, which has been reflected in its activities, including education of its members.

Thirty-day mortality (so called "operative mortality") is defined as death within 30 days of operation regardless of the patient's geographic location and even after the patient has been discharged from the hospital. Hospital mortality is defined as death within any time interval after an operation if the patient has not been discharged from the hospital.

Hospital-to-hospital transfer in the categories of esophageal surgery is not considered discharge: transfer to a nursing home or a rehabilitation unit is considered hospital discharge unless the patient subsequently dies of complications of the operation. On the other hand, hospital-to-hospital transfer 30 days after operation in the categories of cardiovascular surgery and general thoracic surgery is considered discharge because data of the national clinical database (NCD) 2016 were used in this category, and hospital-to-hospital transfer 30 days after operation is considered discharge in the NCD.

Abstract of the survey

All data regarding cardiovascular surgery and thoracic surgery were obtained from the NCD, whereas data regarding esophageal surgery were collected from a survey questionnaire by The Japanese Association for Thoracic Surgery forms because NCD of esophageal surgery does not include non-surgical cases (i.e. patients with adjuvant chemotherapy or radiation alone).

In association with the change in data collection of cardiovascular surgery from self-reports using questionnaire sheets in each participating institution until the report in 2014 to automatic package download from the JCVSD (Japanese Cardiovascular Surgery Database, a cardiovascular part of the NCD), the response rate is not available and is not indicated in the category of cardiovascular surgery (Table 1). Further, the number of institutions classified by operation number is also not calculated in the category of cardiovascular surgery (Table 2).

Annual report by The Japanese Association for Thoracic Surgery: Committee for Scientific Affair.

Shunsuke Endo and Shoji Natsugoe contributed equally.

Extended author information available on the last page of the article

Table 1 Number of institutions involved in the survey

	Questionnaires		
	Sent out	Responded	Response rate (%)
(A) Cardiovascular surgery	–	–	–
(B) General thoracic Surgery	744	693	93.1
(C) Esophageal surgery	584	543	93.0

Table 2 Categories subclassified according to the number of operations performed

Number of operations performed	Category General thoracic surgery
0	5
1–24	52
25–49	119
50–99	185
100–149	130
150–199	89
≥ 200	113
Total	693
Number of operations performed	**Esophageal surgery**
0	70
1–4	138
5–9	107
10–19	95
20–29	41
30–39	26
40–49	22
≥ 50	44
Total	543

2016 Final report

(A) Cardiovascular surgery

First, we are very pleased with our colleagues' (members') cooperation with our survey of cardiovascular surgery, which definitely enhances the quality of this annual report. We are truly grateful again for the enormous effort put into completing the JCVSD/NCD at each participating institution.

Figure 1 shows the development of cardiovascular surgery in Japan over the last 30 years. Aneurysm surgery includes only operations for thoracic and thoracoabdominal aortic aneurysms. Extra-anatomic bypass surgery for thoracic aneurysms and pacemaker implantation were totally excluded from the survey since 2015. The number of assist device implantation operations is not included in the total number of surgical operations, while it remained in the survey.

A total of 67,867 cardiovascular operations, including 51 heart transplantations, were performed at 580 institutions in 2016, which increased by 6.8% from the survey in 2015 (n = 63,520). Considering the trend in 2016, the data of which were collected and aggregated in the same method as in 2015, the actual number of cardiovascular operations is still continuously increasing, although the apparent number decreased in 2015 probably due to a major change in data collection and aggregation.

When compared with the data of 2015 [1] and of 2006 [2], the number of operations in 2016 for congenital heart disease decreased by 3.4% (8744 vs. 9054) and 7.6%, respectively; that for valvular heart disease increased by 16.1% (23,012 vs. 19,820) and 52.5%, respectively; that for thoracic aortic aneurysm increased by 9.4% (19,078 vs. 17,444) and 104.6%, respectively; that for ischemic heart decreased by 1.5% (14,874 vs. 15,103) and 21.1%, respectively; that for other cardiovascular procedures decreased slightly by 1.1% (1874 vs. 1895) and increased by 64.1%, respectively. Data for individual categories are summarized in Tables 3, 4, 5, 6, 7, 8.

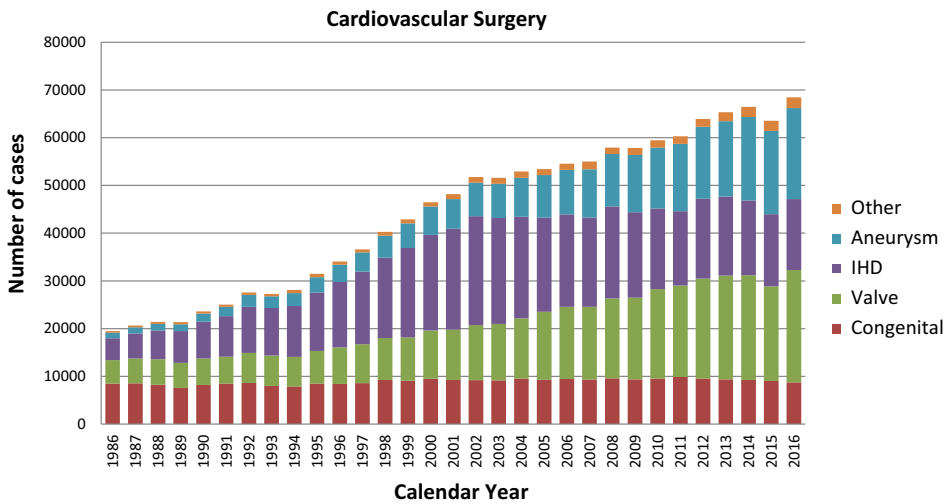

Fig. 1 Cardiovascular surgery. *IHD* ischemic heart disease

Table 3 Congenital (total; 8744)
(1) CPB (+) (total; 6462)

	Neonate				Infant				1–17 years				≥ 18 years				Total			
	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge	
PDA	1	0	0	0	2	0	0	0	0	0	0	0	3	1 (33.3)	0	1 (33.3)	6	1 (16.7)	0	1 (16.7)
Coarctation (simple)	13	1 (7.7)	0	1 (7.7)	12	0	0	0	15	0	0	0	4	0	0	0	44	1 (2.3)	0	1 (2.3)
+ VSD	44	2 (4.5)	1 (2.3)	2 (4.5)	43	2 (4.7)	0	3 (7.0)	14	0	0	0	0	0	0	0	101	4 (4.0)	1 (1.0)	5 (5.0)
+ DORV	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
+ AVSD	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
+ TGA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+ SV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+ Others	10	0	0	0	9	0	0	1 (11.1)	3	0	0	0	1	0	0	0	23	0	0	1 (4.3)
Interrupt. of Ao (simple)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+ VSD	20	1 (5.0)	0	1 (5.0)	24	1 (4.2)	0	1 (4.2)	9	0	0	0	0	0	0	0	53	2 (3.8)	0	2 (3.8)
+ DORV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+ Truncus	6	1 (16.7)	0	1 (16.7)	5	0	0	0	0	0	0	0	0	0	0	0	11	1 (9.1)	0	1 (9.1)
+ TGA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+ Others	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Vascular ring	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
PS	3	1 (33.3)	0	1 (33.3)	27	0	0	0	105	0	0	0	19	0	0	0	154	1 (0.6)	0	1 (0.6)
PA·IVS or critical PS	4	0	0	0	53	1 (1.9)	0	1 (1.9)	63	0	0	0	9	0	0	0	129	1 (0.8)	0	1 (0.8)
TAPVR	100	7 (7.0)	0	12 (12.0)	52	0	0	0	8	0	0	1 (12.5)	0	0	0	0	160	7 (4.4)	0	13 (8.1)
PAPVR ± ASD	0	0	0	0	5	0	0	0	50	0	0	0	13	0	0	0	68	0	0	0
ASD	1	0	0	0	51	0	0	0	608	0	0	0	372	0	2 (0.5)	1 (0.3)	1032	0	2 (0.2)	1 (0.1)
Cor triatriatum	1	0	0	0	6	0	0	0	8	0	0	0	0	0	0	0	15	0	0	0
AVSD (partial)	0	0	0	0	13	1 (7.7)	0	1 (7.7)	36	0	0	0	3	0	0	0	52	1 (1.9)	0	1 (1.9)
AVSD (complete)	4	1 (25.0)	0	1 (25.0)	107	2 (1.9)	0	3 (2.8)	94	1 (1.1)	0	1 (1.1)	2	0	0	0	207	4 (1.9)	0	5 (2.4)
+ TOF or DORV	1	0	0	0	7	1 (14.3)	0	2 (28.6)	12	0	0	1 (8.3)	0	0	0	0	20	1 (5.0)	0	3 (15.0)
+ Others	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VSD (subarterial)	2	0	0	0	88	0	0	0	171	0	0	0	13	0	0	0	274	0	0	0
VSD (perimemb./muscular)	11	0	0	0	825	0	0	1 (0.1)	366	0	0	2 (0.5)	30	0	0	0	1232	0	0	3 (0.2)
VSD (type unknown)	0	0	0	0	0	0	0	0	0	0	0	0	48	0	0	1 (2.1)	48	0	0	1 (2.1)
VSD + PS	2	0	0	0	26	0	0	0	22	0	0	0	0	0	0	0	50	0	0	0
DCRV ± VSD	0	0	0	0	5	0	0	0	23	0	0	0	9	0	0	0	37	0	0	0
Aneurysm of sinus of Valsalva	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5	0	0	0

Table 3 (continued)

	Neonate				Infant				1–17 years				≥ 18 years				Total			
	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge	
TOF	14	0	0	0	162	1 (0.6)	0	2 (1.2)	174	2 (1.1)	0	3 (1.7)	25	0	0	1 (4.0)	375	3 (0.8)	0	6 (1.6)
PA + VSD	9	1 (11.1)	0	1 (11.1)	56	0	0	2 (3.6)	109	0	0	0	10	0	0	0	184	1 (0.5)	0	3 (1.6)
DORV	25	0	0	0	140	2 (1.4)	0	2 (1.4)	158	1 (0.6)	0	2 (1.3)	11	0	0	1 (9.1)	334	3 (0.9)	0	5 (1.5)
TGA (simple)	98	1 (1.0)	0	4 (4.1)	11	0	0	1 (9.1)	2	0	0	0	2	0	0	0	113	1 (0.9)	0	5 (4.4)
+ VSD	37	2 (5.4)	0	4 (10.8)	10	0	0	0	11	1 (9.1)	0	1 (9.1)	2	0	0	0	60	3 (5.0)	0	5 (8.3)
VSD + PS	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0
Corrected TGA	2	0	0	0	8	0	0	0	24	0	0	1 (4.2)	7	0	0	0	41	0	0	1 (2.4)
Truncus arteriosus	6	0	0	0	24	0	0	1 (4.2)	16	0	0	1 (6.3)	1	0	0	0	47	0	0	2 (4.3)
SV	24	2 (8.3)	0	6 (25.0)	181	3 (1.7)	0	7 (3.9)	199	3 (1.5)	0	6 (3.0)	28	2 (7.1)	0	3 (10.7)	432	10 (2.3)	0	22 (5.1)
TA	8	0	0	0	48	2 (4.2)	0	3 (6.3)	48	0	0	1 (2.1)	10	0	0	0	114	2 (1.8)	0	4 (3.5)
HLHS	28	2 (7.1)	0	5 (17.9)	124	3 (2.4)	0	9 (7.3)	74	1 (1.4)	0	3 (4.1)	0	0	0	0	226	6 (2.7)	0	17 (7.5)
Aortic valve lesion	10	1 (10.0)	0	1 (10.0)	22	1 (4.5)	0	4 (18.2)	110	0	0	0	36	2 (5.6)	0	4 (11.1)	178	4 (2.2)	0	9 (5.1)
Mitral valve lesion	1	0	0	1 (100.0)	37	0	0	0	62	0	0	0	11	1 (9.1)	0	1 (9.1)	111	1 (0.9)	0	2 (1.8)
Ebstein	9	1 (11.1)	0	1 (11.1)	15	0	0	0	26	0	0	0	10	0	0	0	60	1 (1.7)	0	1 (1.7)
Coronary disease	4	2 (50.0)	0	2 (50.0)	7	1 (14.3)	0	2 (28.6)	18	1 (5.6)	0	1 (5.6)	2	0	0	0	31	4 (12.9)	0	5 (16.1)
Others	15	0	0	1 (6.7)	24	0	0	0	41	0	0	2 (4.9)	54	0	0	0	134	0	0	3 (2.2)
Conduit failure	0	0	0	0	5	0	0	1 (20.0)	37	0	0	0	12	0	0	0	54	0	0	1 (1.9)
Redo (excluding conduit failure)	5	0	0	0	63	2 (3.2)	0	4 (6.3)	104	1 (1.0)	0	4 (3.8)	63	1 (1.6)	0	1 (1.6)	235	4 (1.7)	0	9 (3.8)
Total	519	26 (5.0)	1 (0.2)	45 (8.7)	2307	23 (1.0)	0	51 (2.2)	2821	11 (0.4)	0	30 (1.1)	815	7 (0.9)	2 (0.2)	14 (1.7)	6462	67 (1.0)	3 (0.0)	140 (2.2)

(), % mortality

CPB cardiopulmonary bypass, *PDA* patent ductus arteriosus, *VSD* ventricular septal defect, *DORV* double outlet right ventricle, *AVSD* atrioventricular septal defect, *TGA* transposition of great arteries, *SV* single ventricle, *Interrupt. of Ao.* interruption of aorta, *PS* pulmonary stenosis, *PA-IVS* pulmonary atresia with intact ventricular septum, *TAPVR* total anomalous pulmonary venous return, *PAPVR* partial anomalous pulmonary venous return, *ASD* atrial septal defect, *TOF* tetralogy of Fallot, *DCRV* double-chambered right ventricle, *TA* tricuspid atresia, *HLHS* hypoplastic left heart syndrome, *RV-PA* right ventricle-pulmonary artery

Table 3 (continued)
(2) CPB (–) (total; 2282)

	Neonate				Infant				1–17 years				≥ 18 years				Total			
	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		
		Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge	Hospital mortality
PDA	344	5 (1.5)	0	12 (3.5)	197	1 (0.5)	0	4 (2.0)	25	0	0	0	3	0	0	0	569	6 (1.1)	0	16 (2.8)
Coarctation (simple)	18	0	0	0	7	0	0	0	3	0	0	0	0	0	0	0	28	0	0	0
+ VSD	38	0	0	0	11	1 (9.1)	0	1 (9.1)	2	0	0	0	0	0	0	0	51	1 (2.0)	0	1 (2.0)
+ DORV	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	4	0	0	0
+ AVSD	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
+ TGA	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
+ SV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+ Others	12	0	0	0	5	0	0	0	1	0	0	0	0	0	0	0	18	0	0	0
Interrupt. of Ao (simple)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+ VSD	26	1 (3.8)	0	1 (3.8)	3	0	0	0	0	0	0	0	0	0	0	0	29	1 (3.4)	0	1 (3.4)
+ DORV	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
+ Truncus	7	2 (28.6)	0	2 (28.6)	3	0	0	0	0	0	0	0	0	0	0	0	10	2 (20.0)	0	2 (20.0)
+ TGA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+ Others	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Vascular ring	3	0	0	0	12	0	0	0	8	0	0	0	0	0	0	0	23	0	0	0
PS	5	0	0	0	9	0	0	0	1	0	0	0	1	0	0	0	16	0	0	0
PA·IVS or critical PS	27	1 (3.7)	0	1 (3.7)	34	1 (2.9)	0	1 (2.9)	6	0	0	0	1	0	0	0	68	2 (2.9)	0	2 (2.9)
TAPVR	13	1 (7.7)	0	1 (7.7)	2	0	0	0	0	0	0	0	0	0	0	0	15	1 (6.7)	0	1 (6.7)
PAPVR ± ASD	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0
ASD	0	0	0	0	2	0	0	0	4	0	0	0	2	0	0	0	8	0	0	0
Cor triatriatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVSD (partial)	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3	0	0	0
AVSD (complete)	50	0	0	1 (2.0)	82	0	1 (1.2)	1 (1.2)	7	0	0	0	0	0	0	0	139	0	1 (0.7)	2 (1.4)
+ TOF or DORV	0	0	0	0	5	0	0	0	2	0	0	0	0	0	0	0	7	0	0	0
+ Others	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VSD (subarterial)	4	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0
VSD (perimemb./muscular)	47	0	0	1 (2.1)	111	1 (0.9)	0	1 (0.9)	5	0	0	0	1	0	0	0	164	1 (0.6)	0	2 (1.2)
VSD + PS	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
DCRV ± VSD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aneurysm of sinus of Valsalva	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOF	16	1 (6.3)	0	1 (6.3)	84	1 (1.2)	0	1 (1.2)	12	0	0	0	3	0	0	0	115	2 (1.7)	0	2 (1.7)

Table 3 (continued)

	Neonate				Infant				1–17 years				≥ 18 years				Total			
	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		
		Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge	Hospital mortality
PA + VSD	20	0	0	0	54	0	0	1 (1.9)	25	1 (4.0)	0	3 (12.0)	1	0	0	0	100	1 (1.0)	0	4 (4.0)
DORV	50	0	0	0	83	0	0	0	16	0	0	0	0	0	0	0	149	0	0	0
TGA (simple)	5	0	0	0	3	0	0	0	0	0	0	0	2	0	0	0	10	0	0	0
+ VSD	9	0	0	0	4	0	0	0	1	0	0	0	1	0	0	0	15	0	0	0
VSD + PS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corrected TGA	4	0	0	0	8	0	0	0	14	0	0	0	4	0	0	0	30	0	0	0
Truncus arteriosus	24	0	0	1 (4.2)	7	0	0	0	2	0	0	0	0	0	0	0	33	0	0	1 (3.0)
SV	68	3 (4.4)	1 (1.5)	6 (8.8)	51	1 (2.0)	0	3 (5.9)	19	0	0	0	2	0	0	0	140	4 (2.9)	1 (0.7)	9 (6.4)
TA	20	0	0	1 (5.0)	21	1 (4.8)	0	1 (4.8)	3	0	0	0	3	0	0	0	47	1 (2.1)	0	2 (4.3)
HLHS	77	2 (2.6)	0	4 (5.2)	25	0	0	0	15	0	0	0	0	0	0	0	117	2 (1.7)	0	4 (3.4)
Aortic valve lesion	6	0	1 (16.7)	2 (33.3)	2	0	0	0	1	0	0	0	0	0	0	0	9	0	1 (11.1)	2 (22.2)
Mitral valve lesion	1	1 (100.0)	0	1 (100.0)	2	0	0	0	4	0	0	0	1	0	0	0	8	1 (12.5)	0	1 (12.5)
Ebstein	6	1 (16.7)	0	1 (16.7)	3	0	0	0	1	0	0	0	0	0	0	0	10	1 (10.0)	0	1 (10.0)
Coronary disease	5	0	0	0	3	0	0	0	1	0	0	0	2	0	0	0	11	0	0	0
Others	10	0	0	0	16	0	0	2 (12.5)	13	3 (23.1)	0	3 (23.1)	5	0	0	0	44	3 (6.8)	0	5 (11.4)
Conduit failure	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Redo (excluding conduit failure)	7	0	0	0	106	0	0	1 (0.9)	126	1 (0.8)	0	1 (0.8)	30	0	0	0	269	1 (0.4)	0	2 (0.7)
Total	931	18 (1.9)	2 (0.2)	36 (3.9)	967	7 (0.7)	1 (0.1)	17 (1.8)	321	5 (1.6)	0	7 (2.2)	63	0	0	0	2282	30 (1.3)	3 (0.13)	60 (2.6)

(), % mortality

CPB cardiopulmonary bypass, *PDA* patent ductus arteriosus, *VSD* ventricular septal defect, *DORV* double outlet right ventricle, *AVSD* atrioventricular septal defect, *TGA* transposition of the great arteries, *SV* single ventricle, *Interrupt. of Ao.* interruption of aorta, *PS* pulmonary stenosis, *PA-IVS* pulmonary atresia with intact ventricular septum, *TAPVR* total anomalous pulmonary venous return, *PAPVR* partial anomalous pulmonary venous return, *ASD* atrial septal defect, *TOF* tetralogy of Fallot, *DCRV* double-chambered right ventricle, *TA* tricuspid atresia, *HLHS* hypoplastic left heart syndrome, *RV-PA* right ventricle-pulmonary artery

Table 3 (continued)
(3) Main procedure

		Neonate				Infant				1–17 years				≥ 18 years				Total			
		Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospitalmortality
			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge	
1	SP Shunt	162	4 (2.5)	1 (0.6)	7 (4.3)	431	5 (1.2)	0	8 (1.9)	49	0	0	1 (2.0)	0	0	0	0	642	9 (1.4)	1 (0.2)	16 (2.5)
2	PAB	270	5 (1.9)	1 (0.4)	11 (4.1)	284	2 (0.7)	1 (0.4)	5 (1.8)	16	0	0	0	0	0	0	0	570	7 (1.2)	2 (0.4)	16 (2.8)
3	Bidirectional Glenn or hemi-Fontan ± α	0	0	0	0	285	2 (0.7)	0	5 (1.8)	114	0	0	1 (0.9)	6	0	0	0	405	2 (0.5)	0	6 (1.5)
4	Damus–Kaye–Stansel operation	3	0	0	0	31	3 (9.7)	0	5 (16.1)	13	0	0	1 (7.7)	1	0	0	0	48	3 (6.3)	0	6 (12.5)
5	PA reconstruction/repair (including redo)	16	0	0	0	138	3 (2.2)	0	4 (2.9)	200	1 (0.5)	0	2 (1.0)	14	0	0	0	368	4 (1.1)	0	6 (1.6)
6	RVOT reconstruction/repair	6	0	0	0	186	0	0	2 (1.1)	303	2 (0.7)	0	3 (1.0)	44	0	0	2 (4.5)	539	2 (0.4)	0	7 (1.3)
7	Rastelli procedure	1	0	0	0	27	0	0	1 (3.7)	106	0	0	0	9	0	0	0	143	0	0	1 (0.7)
8	Arterial switch procedure	138	3 (2.2)	0	7‘(5.1)	26	2 (7.7)	0	2 (7.7)	6	1 (16.7)	0	1 (16.7)	1	0	0	0	171	6 (3.5)	0	10 (5.8)
9	Atrial switch procedure	1	0	0	0	2	0	0	1 (50.0)	7	0	0	1 (14.3)	1	0	0	0	11	0	0	2 (18.2)
10	Double switch procedure	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	7	0	0	0
11	Repair of anomalous origin of CA	3	1 (33.3)	0	1 (33.3)	4	0	0	1 (25.0)	2	0	0	0	1	0	0	0	10	1 (10.0)	0	2 (20.0)
12	Closure of coronary AV fistula	1	0	0	0	4	0	0	0	5	0	0	0	0	0	0	0	10	0	0	0
13	Fontan/TCPC	1	0	0	0	3	0	0	0	364	2 (0.5)	0	7 (1.9)	42	2 (4.8)	0	2 (4.8)	410	4 (1.0)	0	9 (2.2)
14	Norwood procedure	0	0	0	0	18	1 (5.6)	0	3 (16.7)	2	0	0	0	0	0	0	0	20	1 (5.0)	0	3 (15.0)
15	Ventricular septation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Left side AV valve repair (including Redo)	2	0	0	0	43	0	0	0	67	0	0	1 (1.5)	13	0	0	0	125	0	0	1 (0.8)
17	Left side AV valve replace (including Redo)	0	0	0	0	15	0	0	0	37	0	0	1 (2.7)	11	1 (9.1)	0	1 (9.1)	63	1 (1.6)	0	2 (3.2)
18	Right side AV valve repair (including Redo)	15	2 (13.3)	0	2 (13.3)	71	0	0	0	85	1 (1.2)	0	3 (3.5)	57	0	0	0	228	3 (1.3)	0	5 (2.2)
19	Right side AV valve replace (including Redo)	0	0	0	0	1	0	0	0	9	0	0	0	25	1 (4.0)	0	1 (4.0)	35	1 (2.9)	0	1 (2.9)
20	Common AV valve repair (including Redo)	8	3 (37.5)	0	6 (75.0)	19	1 (5.3)	0	3 (15.8)	10	1 (10.0)	0	1 (10.0)	1	0	0	0	38	5 (13.2)	0	10 (26.3)

Table 3 (continued)

		Neonate				Infant				1–17 years				≥ 18 years				Total			
		Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospitalmortality
			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge	
21	Common AV valve replace (including Redo)	1	0	0	1 (100.0)	4	0	0	0	6	0	0	0	3	0	0	1 (33.3)	14	0	0	2 (14.3)
22	Repair of supra-aortic stenosis	2	1 (50.0)	0	1 (50.0)	2	0	0	0	8	0	0	0	1	0	0	0	13	1 (7.7)	0	1 (7.7)
23	Repair of subaortic stenosis (including Redo)	1	0	0	0	11	0	0	0	33	0	0	0	7	0	0	0	52	0	0	0
24	Aortic valve plasty ± VSD Closure	8	1 (12.5)	0	1 (12.5)	10	0	0	2 (20.0)	28	0	0	0	5	0	0	0	51	1 (2.0)	0	3 (5.9)
25	Aortic valve replacement	0	0	0	0	2	0	0	0	35	0	0	0	29	2 (6.9)	0	4 (13.8)	66	2 (3.0)	0	4 (6.1)
26	AVR with annular enlargement	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	10	0	0	0
27	Aortic root replace (except Ross)	0	0	0	0	0	0	0	0	7	0	0	0	10	0	0	0	17	0	0	0
28	Ross procedure	1	0	0	0	4	0	0	0	13	0	0	0					18	0	0	0
29	Bilateral pulmonary artery banding	156	4 (2.6)	1 (0.6)	8 (5.1)	19	1 (5.3)	0	2 (10.5)	0	0	0	0	0	0	0	0	175	5 (2.9)	1 (0.6)	10 (5.7)
Total		796	24 (3.0)	3 (0.4)	45 (5.7)	1640	20 (1.2)	1 (0.1)	44 (2.7)	1542	8 (0.5)	0	23 (1.5)	281	6 (2.1)	0	11 (3.9)	4259	58 (1.4)	4 (0.09)	123 (2.9)

(), % mortality

SP systemic-pulmonary, *PAB* pulmonary artery banding, *PA* pulmonary artery, *RVOT* right ventricular outflow tract, *CA* coronary artery, *AV fistula* arteriovenous fistula, *TCPC* total cavopulmonary connection, *AV valve* atrioventricular valve, *VSD* ventricular septal defect, *AVR* aortic valve replacement

Table 4 Acquired (total, (1) + (2) + (4) + (5) + (6) + (7) + isolated operations for arrhythmia in (3); 40,152
(1) Valvular heart disease (total; 23,254)

	Valve	Cases	Operation						30-Day mortality				Hospital mortality		Redo			
			Mechanical	Bioprosthesis	Ross Procedure	Repair	Unknown	With CABG	Hospital		After discharge				Cases	30-Day mortality		Hospital mortality
									Replace	Repair	Replace	Repair	Replace	Repair		Hospital	After discharge	
Isolated	A	9472	1574	7626	0	272	0	2508	176 (1.9)	4 (1.5)	1 (0.01)	0	283 (3.1)	9 (3.3)	522	26 (5.0)	0	37 (7.1)
	M	4576	539	785		3252	0	827	56 (4.2)	34 (1.0)	0	0	83 (6.3)	48 (1.5)	473	25 (5.3)	0	39 (8.2)
	T	303	10	53		240	0	37	3 (4.8)	7 (2.9)	0	0	4 (6.3)	11 (4.6)	83	5 (6.0)	0	7 (8.4)
	P	10	0	7		3	0	0	1 (14.3)	0	0	0	1 (14.3)	0	6	1 (16.7)	0	1 (16.7)
A + M	A	1352	279	952	0	49	72	247	62	(4.6)	0		104	(7.7)	153	8 (5.2)	0	16 (10.5)
							0											
	M		183	377		792	0											
A + T	A	500	90	370	0	8	32	83	25	(5.0)	1	(0.2)	35	(7.0)	59	7 (11.9)	0	9 (15.3)
							0											
	T		1	5		494	0											
M + T	M	3663	453	967		2176	67	402	70	(1.9)	0		119	(3.2)	400	14 (3.5)	0	22 (5.5)
							0											
	T		1	39		3623	0											
A + M + T	A	1046	192	745	0	38	71	119	41	(3.9)	0		69	(6.6)	118	8 (6.8)	0	10 (8.5)
	M		157	370		491	28											
	T		0	3		1043	0											
Others		2332	2	22	0	28	2280	45	17	(0.7)	1	(0.0)	34	(3.3)	220	2 (0.9)	0	6
Total		23,254						4268	496	(2.1)	3	(0.01)	800	(3.4)	2034	96 (4.7)	0	147 (7.2)

(), % mortality

Number of redo cases is included in total case number of 23,254

CABG coronary artery bypass grafting, *A* aortic valve, *M* mitral valve, *T* tricuspid valve, *P* pulmonary valve

TAVR	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
	2250	15 (0.7)	1 (0.0)	30 (1.3)

Table 4 (continued)

(2) Ischemic heart disease (total, (A) + (B); 14,874)

(A) Isolated CABG (total; (a) + (b); 13,654)

(a-1) On-pump arrest CABG (total; 3023)

	Primary, elective				Primary, emergency				Redo, elective				Redo, emergency				Arterial graft only	Artery graft + SVG	SVG only	Others	Unclear
	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality					
		Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge						
1VD	53	2 (3.8)	0	2 (3.8)	17	1 (5.9)	0	2 (11.8)	2	0	0	0	0	0	0	0	23	25	24	0	0
2VD	343	5 (1.5)	0	8 (2.3)	54	4 (7.4)	0	4 (7.4)	4	0	0	0	0	0	0	0	68	299	30	1	3
3VD	1140	9 (0.8)	1 (0.1)	16 (1.4)	164	10 (6.1)	0	12 (7.3)	9	0	0	0	1	0	0	0	87	1193	27	5	2
LMT	969	17 (1.8)	0	25 (2.6)	256	13 (5.1)	0	20 (7.8)	8	0	0	1 (12.5)	3	0	0	0	113	1064	40	10	9
Total	2505	33 (1.3)	1 (0.0)	51 (2.0)	491	28 (5.7)	0	38 (7.7)	23	0	0	1 (4.3)	4	0	0	0	291	2581	121	16	14
Kawasaki	9	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	5	4	2	0	0
Hemodialysis	244	14 (5.7)	0	18 (7.4)	48	6 (12.5)	0	6 (12.5)	6	0	0	0	1	0	0	0	18	257	19	3	2

(), % mortality

CABG coronary artery bypass grafting, *1VD* one-vessel disease, *2VD* two-vessel disease, *3VD* three-vessel disease, *LMT* left main trunk, *SVG* saphenous vein graft, *LMT* includes LMT alone or LMT with other branch diseases

(a-2) On-pump beating CABG (total; 2077)

	Primary, elective				Primary, emergency				Redo, elective				Redo, emergency				Arterial graft only	Artery graft + SVG	SVG only	Others	Unclear
	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality					
		Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge						
1VD	30	0	0	0	10	1 (10.0)	0	1 (10.0)	2	0	0	0	0	0	0	0	9	24	9	0	0
2VD	164	2 (1.2)	0	3 (1.8)	44	2 (4.5)	0	3 (6.8)	2	0	0	0	1	0	0	0	46	146	18	0	1
3VD	672	10 (1.5)	1 (0.1)	18 (2.7)	180	13 (7.2)	0	27 (15.0)	15	0	0	0	1	0	0	0	109	711	39	4	5
LMT	597	10 (1.7)	0	18 (3.0)	332	22 (6.6)	0	29 (8.7)	23	2 (8.7)	0	2 (8.7)	4	2 (50.0)	0	2 (50.0)	139	756	54	1	6
Total	1463	22 (1.5)	1 (0.1)	39 (2.7)	566	38 (6.7)	0	60 (10.6)	42	2 (4.8)	0	2 (4.8)	6	2 (33.3)	0	2 (33.3)	303	1637	120	5	12
Kawasaki	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Hemodialysis	211	8 (3.8)	0	17 (8.1)	77	8 (10.4)	0	12 (15.6)	8	0	0	0	1	0	0	0	30	243	21	1	2

(), % mortality

CABG coronary artery bypass grafting, *1VD* one-vessel disease, *2VD* two-vessel disease, *3VD* three-vessel disease, *LMT* left main trunk, *SVG* saphenous vein graft, *LMT* LMT alone or LMT with other branch diseases

Table 4 (continued)

(b) Off-pump CABG (total; 8554)

(The present section also includes cases of planned off-pump CABG in which, during surgery, the change is made to an on-pump CABG or on-pump beating-heart procedure)

	Primary, elective				Primary, emergency				Redo, elective				Redo, emergency				Arterial graft only	Artery graft + SVG	SVG only	Others	Unclear
	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality					
		Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge						
1VD	439	2 (0.5)	0	2 (0.5)	50	0	0	0	9	1 (11.1)	0	1 (11.1)	6	3 (50.0)	0	4 (66.7)	360	103	36	3	2
2VD	1222	9 (0.7)	0	16 (1.3)	136	4 (2.9)	0	6 (4.4)	17	0	0	0	3	1 (33.3)	0	1 (33.3)	510	808	40	5	15
3VD	2721	15 (0.6)	0	34 (1.2)	360	10 (2.8)	0	15 (4.2)	28	0	0	0	5	1 (20.0)	0	1 (20.0)	662	2359	56	15	22
LMT	2804	17 (0.6)	0	35 (1.2)	715	25 (3.5)	0	42 (5.9)	31	2 (6.5)	0	2 (6.5)	8	0	0	0	977	2438	95	15	33
Total	7186	43 (0.6)	0	87 (1.2)	1261	39 (3.1)	0	63 (5.0)	85	3 (3.5)	0	3 (3.5)	22	5 (22.7)	0	6 (27.3)	2509	5708	227	38	72
Kawasaki	14	0	0	0	3	1 (33.3)	0	1 (33.3)	0	0	0	0	0	0	0	0	12	4	0	1	0
Hemodialysis	818	20 (2.4)	0	38 (4.6)	139	4 (2.9)	0	10 (7.2)	11	0	0	0	3	1 (33.3)	0	1 (33.3)	229	688	46	2	6

(), % mortality

CABG coronary artery bypass grafting, *1VD* one-vessel disease, *2VD* two-vessel disease, *3VD* three-vessel disease, *LMT* left main trunk, *SVG* saphenous vein graft, *LMT* includes LMT alone or LMT with other branch diseases

(c) Conversion from off-pump CABG to on-pump CABG or on- pump beating-heart CABG during surgery (total; 233)

	Primary, elective				Primary, emergency				Redo, elective				Redo, emergency			
	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		
		Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge	Hospital mortality
Conversion to on-pump CABG arrest heart	28	1 (3.6)	0	1 (3.6)	9	0	0	0	1	1 (100.0)	0	1 (100.0)	2	1 (50.0)	0	1 (50.0)
Conversion to on-pump beating-heart CABG	148	6 (4.1)	0	12 (8.1)	41	4 (9.8)	0	6 (14.6)	3	1 (33.3)	0	1 (33.3)	1	1 (100.0)	0	1 (100.0)
Total	176	7 (4.0)	0	13 (7.4)	50	4 (8.0)	0	6 (12.0)	4	2 (50.0)	0	2 (50.0)	3	2 (66.7)	0	2 (66.7)
Hemodialysis	35	3 (8.6)	0	6 (17.1)	6	0	0	0	0	0	0	0	1	1 (100.0)	0	1 (100.0)

(), % mortality

CABG coronary artery bypass grafting

Table 4 (continued)
(B) Operation for complications of MI (total; 1220)

	Chronic				Acute				Concomitant operation		
	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality			
		Hospital	After discharge			Hospital	After discharge		CABG	MVP	MVR
Infarctectomy or aneurysmectomy	145	4 (2.8)	0	11 (7.6)	16	5 (31.3)	0	5 (31.3)	90	43	17
VSP closure	45	5 (11.1)	0	5 (11.1)	222	71 (32.0)	1 (0.5)	89 (40.1)	81	0	2
Cardiac rupture	35	6 (17.1)	1 (2.9)	8 (22.9)	212	79 (37.3)	0	88 (41.5)	43	0	4
Mitral regurgitation											
(1) Papillary muscle rupture	16	2 (12.5)	0	3 (18.8)	33	7 (21.2)	0	9 (27.3)	19	6	43
(2) Ischemic	309	19 (6.1)	0	32 (10.4)	37	7 (18.9)	0	11 (29.7)	254	229	117
Others	73	5 (6.8)	0	6 (8.2)	77	26 (33.8)	0	34 (44.2)	59	9	7
Total	623	41 (6.6)	1 (0.2)	65 (10.4)	597	195 (32.7)	1 (0.2)	236 (39.5)	546	287	190

(), % mortality

Acute within 2 weeks from the onset of myocardial infarction, *MI* myocardial infarction, *CABG* coronary artery bypass grafting, *MVP* mitral valve repair; MVR, mitral valve replacement; VSP, ventricular septal perforation

(3) Operation for arrhythmia (total; 7168)

	Cases	30-Day mortality		Hospital mortality	Concomitant operation						
					Isolated	Congenital	Valve	IHD	Others	Multiple combination	
		Hospital	After discharge							2 categories	3 categories
Maze	3974	82 (2.1)	0	138 (3.5)	136	168	3459	665	288	712	42
For WPW	1	0	0	0	0	0	0	1	0	0	0
For ventricular tachyarrhythmia	34	1 (2.9)	0	1 (2.9)	4	1	17	18	4	10	1
Others	3159	59 (1.9)	1 (0.03)	104 (3.3)	199	116	2478	671	306	572	48
Total	7168	142 (2.0)	1 (0.01)	243 (3.4)	339	285	5954	1355	598	1294	91

(), % mortality

Except for 339 isolated cases, all remaining 6829 cases are doubly allocated, one for this subgroup and the other for the subgroup corresponding to the concomitant operations

WPW, Wolff–Parkinson–White syndrome; IHD, ischemic heart disease

(4) Operation for constrictive pericarditis (total; 172)

	CPB (+)				CPB (−)			
	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge			Hospital	After discharge	
Total	81	11 (13.6)	0	15 (18.5)	91	7 (7.7)	0	10 (11.0)

(), % mortality

CPB cardiopulmonary bypass

(5) Cardiac tumor (total; 535)

	Cases	30-Day mortality		Hospital mortality	Concomitant operation			
		Hospital	After discharge		AVR	MVR	CABG	Others
Benign tumor	462	2 (0.4)	0	3 (0.6)	15	12	38	111
(Cardiac myxoma)	353	2 (0.6)	0	3 (0.8)	4	7	23	84
Malignant tumor	73	4 (5.5)	0	8 (11.0)	2	1	3	12
(Primary)	12	0	0	1 (8.3)	0	0	1	2

(), % mortality

AVR aortic valve replacement, *MVR* mitral valve replacement, *CABG* coronary artery bypass grafting

(6) HOCM and DCM (total; 310)

	Cases	30-Day mortality		Hospital mortality	Concomitant operation			
		Hospital	After discharge		AVR	MVR	MVP	CABG
Myectomy	120	1 (0.8)	0	2 (1.7)	65	16	17	14
Myotomy	10	0	0	1 (10.0)	4	0	1	1
No-resection	168	8 (4.8)	0	15 (8.9)	33	88	80	21
Volume reduction surgery of the left ventricle	12	1 (8.3)	0	1 (8.3)	0	2	6	4
Total	310	10 (3.2)	0	19 (6.1)	102	106	104	40

(), % mortality

HOCM hypertrophic obstructive cardiomyopathy, *DCM* dilated cardiomyopathy, *AVR* aortic valve replacement, *MVR* mitral valve replacement, *MVP* mitral valve repair, *CABG* coronary artery bypass grafting

Table 4 (continued)
(7) Other open-heart operation (total; 668)

	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
Open-heart operation	383	40 (10.4)	1 (0.3)	54 (14.1)
Non-open-heart operation	285	43 (15.1)	0	53 (18.6)
Total	668	83 (12.4)	1 (0.1)	107 (16.0)

(), % mortality

In 2016, of 8744 operations for congenital heart disease, 6462 open-heart surgeries were performed with overall hospital mortality of 2.2%. The number of operations decreased gradually throughout these 10 years (maximum 7386 cases in 2006), and overall hospital mortality showed a plateau at around 3.0%. In detail, the most common disease was ventricular septal defect (VSD) (perimembranous/muscular) (1232 cases), as in 2015 when VSD became the most common disease for the first time since the inauguration of this survey. Atrial septal defect (ASD) was the "second" most common one (1032 cases) in 2016. It was mainly due to the development and increasing use of commercially available catheter devices for ASD closure. In the last 10 years, hospital mortality for complex congenital heart disease was as follows (2006 [2], 2011 [3], and 2016), complete atrio-septal defect (4.5%, 4.7%, and 3.5%), tetralogy of Fallot (1.9%, 0.7%, and 1.6%), transposition of the great arteries with intact septum (4.4%, 2.5%, and 4.4%) and with ventricular septal defect (9.1%, 3.6%, and 8.3%), single ventricle (6.7%, 4.4%, and 5.1%), and hypoplastic left heart syndrome (16.6%, 14.3%, and 7.5%). Right heart bypass surgery is now commonly performed (405 bidirectional Glenn procedures excluding 48 Damus–Kaye–Stansel procedures and 410 Fontan-type procedures including total cavo-pulmonary connection) with acceptable hospital mortality (1.5% and 2.2%, respectively). The Norwood type I procedure was performed in 20 cases, with a relatively low hospital mortality rate of 15%.

The total number of operations for valvular heart disease is increasing, although the apparent number dropped in the survey in 2015, probably because of a major change in the process of data collection. The number of isolated aortic valve replacements/repairs with/without CABG (n = 9472) increased by 9.5% from the previous year (8651) and by 10.3% from 5 years ago (n = 8589), although trans-catheter aortic valve replacement (TAVR or TAVI) was introduced in 2013 and is rapidly spreading.

The hospital mortality of single valve placement was 3.1% and 6.3% for the aortic and mitral positions, while that for mitral valve repair was only 1.5%. The hospital mortality for redo valve surgery was 7.1% in the aortic and 8.2% in the mitral positions, respectively. Finally, overall hospital mortality did not show a dramatic improvement over the last 10 years (4.0% in 2006 [2], 3.4% in 2011 [3], and 3.5% in 2016), which might be partially due to the recent increasing age of the patients. Repair of the valve became a common procedure (367 cases of aortic, 6711 cases of mitral, and 5400 cases tricuspid), and mitral valve repair constituted 29.2% of all valvular operations and 64.4% of all mitral valve procedures, which are similar to those of the last 5 years. Aortic and mitral valve replacements with bioprostheses were performed in 9693 cases and 2499 cases, respectively. The ratio of bioprostheses was 81.9% in the aortic and 65.2%

Table 5 Thoracic aortic aneurysm (total; 19,078)
(1) Dissection (total; 9441)

Stanford type	Acute								Chronic								Concomitant operation						Redo			
	A				B				A				B													
Replaced site	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	AVP	AVR	MVP	MVR	CABG	Others	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge			Hospital	After discharge			Hospital	After discharge			Hospital	After discharge									Hospital	After discharge	
1. Ascending Ao.	2738	241 (8.8)	0	286 (10.4)	3	0	0	0	299	13 (4.3)	0	20 (6.7)	7	0	0	0	128	162	19	14	162	74	109	16 (14.7)	0	18 (16.5)
2. Aortic Root	190	38 (20.0)	0	42 (22.1)	0	0	0	0	58	5 (8.6)	0	7 (12.1)	3	0	0	0	31	159	4	0	68	15	34	6 (17.6)	0	7 (20.6)
3. Arch	1426	128 (9.0)	1 (0.07)	161 (11.3)	34	2 (5.9)	0	2 (5.9)	296	6 (2.0)	0	10 (3.4)	205	10 (4.9)	0	17 (8.3)	55	65	4	1	87	38	125	12 (9.6)	0	15 (12.0)
4. Aortic root + Asc.Ao. + arch	180	28 (15.6)	0	32 (17.8)	0	0	0	0	51	2 (3.9)	0	3 (5.9)	7	1 (14.3)	0	1 (14.3)	24	111	3	1	42	10	26	5 (19.2)	0	6 (23.1)
5. Descending Ao.	64	2 (3.1)	0	4 (6.3)	29	1 (3.4)	0	5 (17.2)	67	0	0	0	254	7 (2.8)	0	15 (5.9)	8	6	0	0	4	4	118	4 (3.4)	0	10 (8.5)
6. Thoracoabdominal Ao.	12	0	0	0	15	2 (13.3)	0	2 (13.3)	29	1 (3.4)	0	1 (3.4)	187	11 (5.9)	0	14 (7.5)	0	0	0	0	1	0	102	6 (5.9)	0	8 (7.8)
7. Stent graft*a	851	79 (9.3)	0	93 (10.9)	469	33 (7.0)	0	46 (9.8)	461	5 (1.1)	0	13 (2.8)	1506	22 (1.5)	1 (0.1)	36 (2.4)	31	90	2	4	92	28	683	20 (2.9)	0	31 (4.5)
1) TEVAR I*b	85	13 (15.3)	0	15 (17.6)	418	27 (6.5)	0	40 (9.6)	287	2 (0.7)	0	5 (1.7)	1262	15 (1.2)	1 (0.1)	26 (2.1)	0	2	0	0	0	9	553	13 (2.4)	0	22 (4.0)
2) Open stent	766	66 (8.6)	0	78 (10.2)	51	6 (11.8)	0	6 (11.8)	174	3 (1.7)	0	8 (4.6)	244	7 (2.9)	0	10 (4.1)	31	88	2	4	92	19	130	7 (5.4)	0	9 (6.9)
a) With total arch*c	756	64 (8.5)	0	76 (10.1)	40	3 (7.5)	0	3 (7.5)	164	3 (1.8)	0	8 (4.9)	195	6 (3.1)	0	8 (4.1)	31	86	2	4	89	19	112	6 (5.4)	0	8 (7.1)
b) without total arch*d	10	2 (20.0)	0	2 (20.0)	11	3 (27.3)	0	3 (27.3)	10	0	0	0	49	1 (2.0)	0	2 (4.1)	0	2	0	0	3	0	18	1 (5.6)	0	1 (5.6)
Total	5461	516 (9.4)	1 (0.02)	618 (11.3)	550	38 (6.9)	0	55 (10.0)	1261	32 (2.5)	0	54 (4.3)	2169	51 (2.4)	1 (0.0)	83 (3.8)	277	593	32	20	456	169	1197	69 (5.8)	0	95 (7.9)

(), % mortality

Acute, within 2 weeks from the onset

Ao aorta, *AVP* aortic valve repair, *AVR* aortic valve replacement, *MVP* mitral valve repair, *MVR* mitral valve replacement, *CABG* coronary artery bypass grafting, *TEVAR* thoracic endovascular aortic (aneurysm) repair

*a = *b + *c + *d

Table 5 (continued)
(2) Non-dissection (total; 9637)

Replaced site	Unruptured				Ruptured				Concomitant operation						Redo			
	Cases	30-Day mortality		Hospital mortality	Cases	30-Day mortality		Hospital mortality	AVP	AVR	MVP	MVR	CABG	Others	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge			Hospital	After discharge									Hospital	After discharge	
1. Ascending Ao.	1528	30 (2.0)	0	45 (2.9)	53	5 (9.4)	0	9 (17.0)	85	1048	89	50	201	240	196	12 (6.1)	0	23 (11.7)
2. Aortic Root	864	25 (2.9)	0	31 (3.6)	52	8 (15.4)	0	10 (19.2)	193	593	62	20	126	133	152	17 (11.2)	0	20 (13.2)
3. Arch	1729	46 (2.7)	1 (0.06)	83 (4.8)	130	13 (10.0)	0	22 (16.9)	42	276	16	9	295	112	185	10 (5.4)	0	20 (10.8)
4. Aortic Root + Asc.Ao. + Arch	254	11 (4.3)	0	14 (5.5)	8	3 (37.5)	0	4 (50.0)	55	161	17	7	40	38	43	8 (18.6)	0	10 (23.3)
5. Descending Ao.	307	7 (2.3)	0	15 (4.9)	64	15 (23.4)	0	19 (29.7)	2	13	0	0	29	5	75	5 (6.7)	0	10 (13.3)
6. Thoracoabdominal Ao.	349	16 (4.6)	0	24 (6.9)	42	7 (16.7)	0	12 (28.6)	0	1	0	0	7	1	88	9 (10.2)	0	13 (14.8)
7. Stent graft*a	3837	97 (2.5)	1 (0.03)	170 (4.4)	420	66 (15.7)	3 (0.71)	87 (20.7)	22	108	22	3	212	74	830	42 (5.1)	1 (0.1)	65 (7.8)
1) TEVARl*b	2727	59 (2.2)	1 (0.04)	102 (3.7)	336	55 (16.4)	3 (0.89)	72 (21.4)	0	4	0	0	16	24	713	31 (4.3)	1 (0.1)	49 (6.9)
2) Open stent	1110	38 (3.4)	0	68 (6.1)	84	11 (13.1)	0	15 (17.9)	22	104	22	3	196	50	117	11 (9.4)	0	16 (13.7)
a) with total arch*c	983	34 (3.5)	0	62 (6.3)	65	9 (13.8)	0	12 (18.5)	21	99	22	3	186	47	93	9 (9.7)	0	13 (14.0)
b) without total arch*d	127	4 (3.1)	0	6 (4.7)	19	2 (10.5)	0	3 (15.8)	1	5	0	0	10	3	24	2 (8.3)	0	3 (12.5)
Total	8868	232 (2.6)	2 (0.02)	382 (4.3)	769	117 (15.2)	3 (0.39)	163 (21.2)	399	2200	206	89	910	603	1569	103 (6.6)	1 (0.1)	161 (10.3)

(), % Mortality

Ao aorta, *AVP* aortic valve repair, *AVR* aortic valve replacement, *MVP* mitral valve repair, *MVR* mitral valve replacement, *CABG* coronary artery bypass grafting, *TEVAR* thoracic endovascular aortic(aneurysm) repair

*a = *b + *c + *d

Table 6 Pulmonary thromboembolism (total; 138)

	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
Acute	90	10 (11.1)		11
Chronic	48	2 (4.2)		3
Total	138	12 (8.7)	0	14 (10.1)

(), % mortality

Table 7 Implantation of VAD (total; 164)

	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
Implantation of VAD	164	3 (1.8)	3 (1.8)	31 (18.9)

(), % mortality

VAD ventricular assist devise

Table 8 Heart transplantation (total; 51)

	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
Heart transplantation	51	1 (2.0)	0	2 (3.9)
Heart and lung transplantation	0	0	0	0
Total	51	1 (2.0)	0	2 (3.9)

(), % mortality

in the mitral positions. This ratio of using bioprostheses increased dramatically from 30 to 40% in the early 2000s [4, 5]. CABG was performed as a concomitant procedure in 18.5% of all valvular operations (15.1% in 2006 [2] and 17.5% in 2011 [3]).

Isolated CABG was performed in 13,654 cases, only 76.1% of that 10 years ago (n = 17,941) [2]. Among these, off-pump CABG was intended in 8554 cases (62.6%), with a success rate of 97.3%, so that the final success rate of off-pump CABG was 60.9%. The percentage of intended off-pump CABG reached 60.3% in 2004 [4], and it was then kept at over 60% until now. In 13,654 isolated CABG patients, 13,029 patients (95.4%) received at least one arterial graft, while all-arterial-graft CABG was performed in only 3103 patients or 22.7% of them. The operative and hospital mortality rates associated with primary elective CABG procedures in 11,154 cases were 0.9% and 1.6%, respectively. A similar data analysis of CABG including primary/redo and elective/emergency data was begun in 2003 [5], and the operative and hospital mortality rates associated with primary elective CABG procedures in 2003 were 1.0% and 1.5%, respectively, so that the operative results of primary CABG have been stable. Hospital mortality of primary emergency CABG in 2318 cases was still high, at 6.9%. The conversion from off-pump CABG rate was 2.7%, with hospital mortality of 9.9%. A total of 1220 patients underwent surgery for complications of myocardial infarction, including 675 operations for left ventricular aneurysm, ventricular septal perforation, or cardiac rupture and 395 operations for ischemic mitral regurgitation. In this report, the number of concomitant coronary artery bypass grafting (CABG) procedures with other major procedures is not included in the category of ischemic heart disease but in other categories such as valvular heart disease and thoracic aneurysm; then, the overall number of CABG procedure including concomitant CABG with other major procedures still remained at over 20,000 cases per year (20,589 cases) in 2016.

Operations for arrhythmia were performed mainly as a concomitant procedure in 7168 cases, with a 24.3% increase compared with that of 2015. Implantations of pacemakers and ICDs are not included in this category. The hospital mortality of arrhythmia surgery including 3974 MAZE procedures was 3.4%. The MAZE procedure has become a quite common procedure (2944 cases in 2006 [2], and 3771 cases in 2011 [3]).

In 2016, 19,078 operations were performed for diseases of the thoracic and thoracoabdominal aortae: 9441 for aortic dissection and 9637 for non-dissection. The number of operations for aortic dissection increased by 10.5% this year compared with the previous year (n = 8547). The hospital mortality of operations for 5461 Stanford type A acute aortic dissections remained as high as 11.3%. The number of operations for non-dissected aneurysm increased by 8.3%, with overall hospital mortality of 5.7% (4.3% and 21.2% for unruptured and ruptured aneurysms, respectively).

The number of stent graft procedures has recently increased remarkably. Most importantly, the number of open stent grafts with total arch replacement strikingly increased 5 times (228–1155) and 3.4 times (308–1048) in dissecting and non-dissecting aortic aneurysms, respectively. This must be associated with the commercial

availability of special designed device for open stent grafting since 2014.

A total of 3287 patients with aortic dissection underwent stent graft placement: 2052 thoracic endovascular aortic repair (TEVAR) and 1235 open stent grafting. The number of TEVAR procedures for type B chronic aortic dissections increased by 41.4% from 1065 cases in 2015 to 1506 cases in 2016. The hospital mortality rates associated with TEVAR for type B aortic dissection were 9.6% and 2.1% in acute and chronic cases, respectively.

A total of 4257 patients with non-dissected aortic aneurysms underwent stent graft placement, consisting of 3063 TEVAR [5.2% increase compared with 2015 (n = 2912)] and 1194 open stent grafts [27.4% increase compared with 2015 (n = 937)]. The hospital mortality rates for TEVAR and open stenting were as follows: TEVAR, 3.7% for unruptured and 21.4% for ruptured aneurysms; open stent grafting, 6.1% for unruptured and 17.9% for ruptured aneurysms.

(B) General thoracic surgery

The 2016 survey of general thoracic surgery comprised 693 surgical units, and most data were submitted through the web-based collection system of the national clinical database (NCD) [6]. In total, 82,193 operations were reported by general thoracic surgery departments in 2016, 1.9 times the number of operations in 2001 and 2418 more operations than in 2015, while the number of surgical units submitting reports to this survey decreased by 43 due to conversion of the data collection system since 2014 (Fig. 2).

Table 9 Total cases of general thoracic surgery during 2016

	Cases	%
Benign pulmonary tumor	2124	2.6
Primary lung cancer	42,107	51.2
Other primary malignant pulmonary tumor	375	0.5
Metastatic pulmonary tumor	8497	10.3
Tracheal tumor	122	0.1
Mesothelioma	634	0.8
Chest wall tumor	664	0.8
Mediastinal tumor	5026	6.1
Thymectomy for MG without thymoma	145	0.2
Inflammatory pulmonary disease	2142	2.6
Empyema	2833	3.4
Bullous disease excluding pneumothorax	436	0.5
Pneumothorax	14,867	18.1
Chest wall deformity	189	0.2
Diaphragmatic hernia including traumatic	37	0.0
Chest trauma excluding diaphragmatic hernia	426	0.5
Lung transplantation	75	0.1
Others	1494	1.8
Total	82,193	100.0

In 2016, 42,107 operations for primary lung cancer were performed (Table 9), and the number has increased every year. The 2016 value is 2.2 times that of 2001. Operations for lung cancer accounted for 51.2% of all procedures in general thoracic surgery.

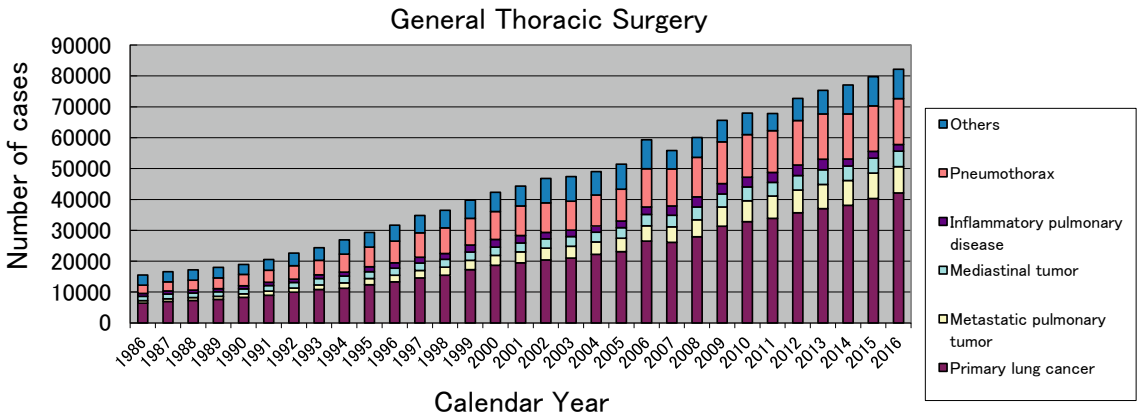

Fig. 2 General thoracic surgery

Table 10 Benign pulmonary tumor

	Cases	30-Day mortality		Hospital mortality	by VATS
		Hospital	after discharge		
Benign pulmonary tumor					
Hamartoma	442	0	0	1 (0.2)	423
Sclerosing hemangioma	96	0	0	0	94
Papilloma	17	0	0	0	16
Mucous gland adenoma bronchial	6	0	0	0	5
Fibroma	118	0	1 (0.8)	0	110
Lipoma	10	0	0	0	7
Neurogenic tumor	15	0	0	0	13
Clear cell tumor	5	0	0	0	5
Leiomyoma	15	0	0	0	14
Chondroma	7	0	0	0	6
Inflammatory myofibroblastic tumor	2	0	0	0	2
Pseudolymphoma	39	0	0	0	37
Histiocytosis	9	0	0	0	8
Teratoma	6	0	0	0	5
Others	1337	0	0	1 (0.1)	1270
Total	2124	0	1 (0.05)	2 (0.1)	2015

(), Mortality %

The number of video-assisted thoracic surgery (VATS) operations, defined as a surgical procedure using a skin incision longer than 8 cm and/or a minithoracotomy (hybrid) approach, has been described since the Annual Report 2015. The number of VATS operations for benign pulmonary tumor, primary lung cancer, and the total number of VATS operations in 2016 are shown in Tables 10, 11, 13, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, and 29, respectively.

There were 2124 operations for benign pulmonary tumors in 2016, similar to the number in 2015 (Table 10). Hamartoma was the most frequent diagnosis in operations for benign pulmonary tumors. VATS was performed in 2015 patients (94.7%).

Table 11 Primary malignant pulmonary tumor

	Cases	30-Day mortality		Hospital mortality	VATS
		Hospital	After discharge		
Primary malignant pulmonary tumor	42,482	118 (0.3)	52 (0.1)	242 (0.6)	28,568
Lung cancer	42,107	115 (0.3)	52 (0.1)	237 (0.6)	28,568
Adenocarcinoma	29,607	53 (0.2)	24 (0.1)	96 (0.3)	
Squamous cell carcinoma	7877	40 (0.5)	17 (0.2)	102 (1.3)	
Large cell carcinoma	791	1 (0.1)	4 (0.5)	5 (0.6)	
(*LCNEC*)	480	0	2 (0.4)	2 (0.4)	
Small cell carcinoma	755	6 (0.8)	2 (0.3)	10 (1.3)	
Adenosquamous carcinoma	574	6 (1.0)	1 (0.2)	8 (1.4)	
Carcinoma with pleomorphic, sarcomatoid or sarcomatous elements	468	4 (0.9)	1 (0.2)	7 (1.5)	
Carcinoid	251	0	1 (0.4)	0	
Carcinomas of salivary-gland type	33	0	0	0	
Unclassified	59	0	0	0	
Multiple lung cancer	1327	3 (0.2)	1 (0.1)	7 (0.5)	
Others	365	2 (0.5)	1 (0.3)	2 (0.5)	
Wedge resection	6275	8 (0.1)	9 (0.1)	19 (0.3)	5395
Segmental excision	4391	8 (0.18)	1 (0.0)	13 (0.3)	3265
(*Sleeve segmental excision*)	16	0	0	0	5
Lobectomy	30,597	86 (0.3)	37 (0.1)	176 (0.6)	19,697
(*Sleeve lobectomy*)	481	3 (0.6)	1 (0.2)	7 (1.5)	92
Pneumonectomy	477	8 (1.7)	3 (0.6)	22 (4.6)	39
(*Sleeve pneumonectomy*)	15	1 (6.7)	0	5 (33.3)	2
Other bronchoplasty	48	1 (2.1)	0	1 (2.1)	0
Pleuropneumonectomy	3	1 (33.3)	0	1 (33.3)	0
Others	316	3 (0.9)	2 (0.6)	5 (1.6)	172
Unknown	0	0	0	0	
Sarcoma	49	1 (2.0)	0	2 (4.1)	
AAH	131	0	0	0	
Others	195	2 (1.0)	0	3 (1.5)	

(), Mortality %

Additional information on primary malignant pulmonary tumors is shown in Tables 11 and 12. With regard to lung cancer subtype, adenocarcinoma was by far the most frequent diagnosis (70.3% of all lung cancer operations), followed by squamous cell carcinoma (18.7%). Sublobar resection was performed in 10,666 lung cancer

Table 12 Details of lung cancer operations

TNM	
c-Stage	Cases
Ia	25,963
Ib	7947
IIa	3149
IIb	1796
IIIa	2459
IIIb	175
IV	441
NA	177
Total	42,107
Sex	Cases
Male	25,716
Female	16,391
NA	0
Total	42,107
Cause of death	Cases
Cardiovascular	32
Pneumonia	42
Pyothorax	3
Bronchopleural fistula	18
Respiratory failure	29
Pulmonary embolism	2
Interstitial pneumonia	84
Brain infarction or bleeding	6
Others	62
Unknown	11
Total	289
p-Stage	Cases
0 (pCR)	634
Ia	22,249
Ib	8334
IIa	3354
IIb	2131
IIIa	4029
IIIb	180
IV	1013
NA	183
Total	42,107
Age (years)	Cases
< 20	32
20–29	45
30–39	233
40–49	1154
50–59	3710
60–69	14,181
70–79	17,491
80–89	5187
≥ 90	74
NA	0
Total	42,107

cases (25.1% of all cases), and lobectomy was performed in 30,597 cases (72.0% of all cases). Sleeve lobectomy was performed in 481 cases, and pneumonectomy was required in 477 cases (1.1% of all cases). VATS lobectomy for lung cancer was performed in 19,697 cases (64.3% of all lobectomy cases). The number of VATS procedures for primary lung cancer was slightly higher than in 2015. The number of patients aged 80 years or older who underwent lung cancer surgery was 5279 (12.5%). In total, 115 patients died before hospital discharge within 30 days after surgery, and 52 patients died after discharge within 30 days after surgery. Therefore, 167 patients died within 30 days after surgery (30-day mortality rate, 0.4%). In total, 237 patients died before discharge (hospital mortality rate, 0.6%), and the 30-day mortality rate, by procedure, was 0.3% for segmentectomy, 0.6% for lobectomy, and 4.6% for pneumonectomy. Interstitial pneumonia was the leading cause of death after lung cancer surgery, followed by pneumonia, cardiovascular events, and respiratory failure. The risk calculators for mortality and morbidity, such as broncho-pleural fistula and respiratory failure, after lung cancer surgery based on the NCD are now available [7, 8].

Operations for metastatic pulmonary tumors are shown in Table 13; 8497 operations were performed in 2016. Colorectal cancer was the most frequent diagnosis (47.7% of all cases).

There were 122 operations for malignant tracheal tumor in 2016, but only 29 patients were treated with curative intent (Table 14).

There were 634 pleural tumors in 2016 (Table 15). Diffuse malignant pleural mesothelioma was the most frequent histologic diagnosis. Total pleurectomy was performed in 73 cases, and extrapleural pneumonectomy was performed in 64 cases. The hospital mortality rate was 0% after total pleurectomy and 1.6% after extrapleural pneumonectomy, which were better than the previous outcomes.

In total, 664 chest wall tumors were resected in 2016 (Table 16), of which 346 (52.1%) were benign. Among the 318 malignant chest wall tumors, 207 (65.1%) were metastatic tumors.

Table 13 Metastatic pulmonary tumor

	Cases	30-Day mortality		Hospital mortality	VATS
		Hospital	After discharge		
Metastatic pulmonary tumor	8497	11 (0.1)	9 (0.1)	20 (0.2)	7909
Colorectal	4052	4 (0.1)	3 (0.1)	8 (0.2)	3766
Hepatobiliary/pancreatic	400	1 (0.3)	0	1 (0.3)	381
Uterine	431	1 (0.2)	0	1 (0.2)	410
Mammary	472	0	1 (0.2)	0	444
Ovarian	69	0	0	0	64
Testicular	61	0	0	0	57
Renal	724	0	0	1 (0.1)	688
Skeletal	140	0	0	0	130
Soft tissue	213	0	0	0	192
Otorhinolaryngological	459	2 (0.4)	1 (0.2)	2 (0.4)	430
Pulmonary	549	1 (0.2)	2 (0.4)	3 (0.5)	471
Others	927	2 (0.2)	2 (0.2)	4 (0.4)	876

(), Mortality %

Table 14 Tracheal tumor

	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
Tracheal tumor	122	4 (3.3)	0	5 (4.1)
A. Primary malignant tumor				
Histological classification				
Squamous cell carcinoma	15	0	0	1 (6.7)
Adenoid cystic carcinoma	20	1 (5.0)	0	1 (5.0)
Mucoepidermoid carcinoma	0	0	0	0
Others	11	0	0	0
Total	46	1 (2.2)	0	2 (4.3)
B. Metastatic/invasive malignant tumor				
e.g. invasion of thyroid cancer	36	3 (8.3)	0	3 (8.3)
C. Benign tracheal tumor				
Histological classification				
Papilloma	6	0	0	0
Adenoma	2	0	0	0
Neurofibroma	0	0	0	0
Chondroma	0	0	0	0
Leiomyoma	4	0	0	0
Others	28	0	0	0
Histology unknown	0	0	0	0
Total	40	0	0	0
Operation				
Sleeve resection with reconstruction	27	0	0	0
Wedge with simple closure	0	0	0	0
Wedge with patch closure	1	0	0	0
Total laryngectomy with tracheostomy	1	0	0	0
Others	4	1 (25.0)	0	1 (25.0)
Unknown	0	0	0	0
Total	33	1 (3.0)	0	1 (3.0)

(), Mortality %

Table 15 Tumor of pleural origin

Histological classification	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
Tumor of pleural origin				
Solitary fibrous tumor	122	0	0	0
Diffuse malignant pleural mesothelioma	247	1 (0.4)	0	2 (0.8)
Localized malignant pleural mesothelioma	42	0	0	0
Others	223	4 (1.8)	1 (0.4)	8 (3.6)
Total	634	5 (0.8)	1 (0.2)	10 (1.6)

Operative procedure	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
Extrapleural pneumonectomy	64	0	0	1 (1.6)
Total pleurectomy	73	0	0	0
Others	110	1 (0.9)	0	1 (0.9)
Total	247	1 (0.4)	0	2 (0.8)

(), Mortality %

Mediastinal tumors were resected in 5026 patients, a slight increase from the previous year (Table 17). Thymic epithelial tumor, including 1986 thymomas, 314 thymic carcinomas, and 40 thymic carcinoids, was the most frequent mediastinal tumor type in 2016.

Thymectomy for myasthenia gravis was performed in 478 patients (Table 18); 333 operations were associated with thymoma, and the remaining were not associated with thymoma.

Operations for non-neoplastic disease were performed in 22,424 patients. There were 2142 cases of lung resection for inflammatory lung diseases (Table 19); 21.7% of the cases were associated with atypical mycobacterium infections, and 15.2% were fungal infections. An operation for inflammatory nodules was performed because lung cancer was suspected before surgery in 913 cases (42.6%)

The 2833 operations for empyema (Table 20) included 2085 cases (73.6%) of acute empyema and 748 cases of chronic empyema. A bronchopleural fistula was reported in 470 patients with acute empyema and 359 patients with chronic empyema. The hospital mortality rate was 18.3% in patients with acute empyema with fistula.

There were 100 operations for descending necrotizing mediastinitis (Table 21). The hospital mortality rate was 14.0%.

There were 436 operations for bullous diseases (Table 22). Lung volume reduction surgery was performed in only 18 patients.

A total of 14,867 operations were performed for spontaneous pneumothorax (Table 23). The 11,835 operations for primary pneumothorax included 3028 patients (25.6%) who underwent bullectomy only and 7966 patients (67.3%) who underwent an additional procedure. There were 3032

Table 16 Chest wall tumor

	Cases	30-Day mortality		Hospital mortality	VATS
		Hospital	After discharge		
Chest wall tumor					
Primary malignant tumor	111	0	0	0	54
Metastatic malignant tumor	207	1 (0.5)	0	2 (1.0)	93
Benign tumor	346	0	0	0	267
Total	664	1 (0.2)	0	2 (0.3)	414

(), Mortality %

Table 17 Mediastinal tumor

	Cases	30-Day mortality		Hospital mortality	By VATS
		Hospital	After discharge		
Mediastinal tumor	5026	6 (0.1)	3 (0.06)	9 (0.2)	3636
Thymoma	1986	2 (0.1)	2 (0.1)	2 (0.1)	1218
Thymic cancer	314	2 (0.6)	1 (0.3)	2 (0.6)	164
Thymus carcinoid	40	0	0	0	20
Germ cell tumor	84	0	0	0	47
Benign	56	0	0	0	34
Malignant	28	0	0	0	13
Neurogenic tumor	447	0	0	0	419
Congenital cyst	1111	0	0	0	993
Goiter	81	0	0	1 (1.2)	31
Lymphatic tumor	182	2 (1.1)	0	2 (1.1)	136
Excision of pleural recurrence of thymoma	31	0	0	0	27
Thymolipoma	22	0	0	0	17
Others	728	0	0	2 (0.3)	564

(), Mortality %

Table 18 Thymectomy for myasthenia gravis

	Cases	30-Day mortality		Hospital mortality	by VATS
		Hospital	After discharge		
Thymectomy for myasthenia gravis	478	2 (0.4)	1 (0.2)	2 (0.4)	276
With thymoma	333	2 (0.6)	1 (0.3)	2 (0.6)	189

(), Mortality %

operations for secondary pneumothorax. COPD was by far the most prevalent associated disease (70.7%). The hospital mortality rate for secondary pneumothorax associated with COPD was 2.8%.

The 2016 survey reported 181 operations for chest wall deformity (Table 24). However, this might be an underestimate, because the Nuss procedure for pectus excavatum was more likely to have been performed in pediatric surgery centers not associated with JATS.

Table 19 Operations for non-neoplastic diseases

	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
Operations for non-neoplastic diseases	22,424	195 (0.9)	20 (0.1)	466 (2.1)

	Cases	30-Day mortality		Hospital mortality	VATS
		Hospital	After discharge		
A. Inflammatory pulmonary disease	2142	6 (0.3)	1 (0.0)	16 (0.7)	1948
Tuberculous infection	41	0	0	0	38
Mycobacterial infection	464	0	0	3 (0.6)	423
Fungal infection	326	1 (0.3)	1 (0.3)	4 (1.2)	255
Bronchiectasis	58	0	0	0	47
Tuberculous nodule	88	0	0	0	83
Inflammatory pseudotumor	774	3 (0.4)	0	4 (0.5)	751
Interpulmonary lymph node	51	0	0	0	50
Others	340	2 (0.6)	0	5 (1.5)	301

(), Mortality %

Table 20 B. Empyema

	Cases	30-Day mortality		Hospital mortality	by VATS
		Hospital	After discharge		
Acute empyema	2085	50 (2.4)	5 (0.2)	150 (7.2)	1758
With fistula	470	24 (5.1)	1 (0.2)	86 (18.3)	272
Without fistula	1596	26 (1.6)	4 (0.3)	63 (3.9)	1469
Unknown	19	0	0	1 (5.3)	17
Chronic empyema	748	19 (2.5)	2 (0.3)	45 (6.0)	442
With fistula	359	15 (4.2)	2 (0.6)	26 (7.2)	160
Without fistula	355	4 (1.1)	0	16 (4.5)	257
Unknown	34	0	0	3 (8.8)	25
Total	2833	69 (2.4)	7 (0.2)	195 (6.9)	2200

(), Mortality %

Table 21 C. Descending necrotizing mediastinitis

	Cases	30-Day mortality		Hospital mortality	VATS
		Hospital	After discharge		
C. Descending necrotizing mediastinitis	100	7 (7.0)	0	14 (14.0)	71

(), Mortality %

Table 22 D. Bullous diseases

	Cases	30-Day mortality		Hospital mortality	VATS
		Hospital	After discharge		
D. Bullous diseases	436	2 (0.5)	0	3 (0.7)	405
Emphysematous bulla	354	0	0	1 (0.3)	331
Bronchogenic cyst	15	0	0	0	14
Emphysema with LVRS	18	0	0	0	17
Others	49	2 (4.1)	0	2 (4.1)	43

(), Mortality %

LVRS lung volume reduction surgery

Diaphragmatic hernia was treated surgically in 37 patients (Table 25). This figure might be an underestimate, since some procedures might have been classified as gastrointestinal surgery.

The survey reported 426 procedures for chest trauma excluding iatrogenic injuries (Table 26). The hospital mortality rate was 7.3%.

Table 23 E. Pneumothorax

Cases	30-Day mortality		Hospital mortality
	Hospital	After discharge	
14,867	57 (0.4)	11 (0.1)	129 (0.9)

Spontaneous pneumothorax

Operative procedure	Cases	30-Day mortality		Hospital mortality	VATS
		Hospital	After discharge		
Bullectomy	3028	2 (0.1)	1 (0.0)	8 (0.3)	2986
Bullectomy with additional procedure	7966	9 (0.11)	0	12 (0.2)	7860
Coverage with artificial material	7564	7 (0.09)	0	9 (0.1)	7461
Parietal pleurectomy	53	1 (1.9)	0	1 (1.9)	52
Coverage and parietal pleurectomy	73	1 (1.4)	0	1 (1.4)	73
Others	276	0	0	1 (0.4)	274
Others	836	6 (0.7)	1 (0.1)	11 (1.3)	771
Unknown	5	0	0	0	5
Total	11,835	17 (0.1)	2 (0.02)	31 (0.3)	11,622

Secondary pneumothorax

Associated disease	Cases	30-Day mortality		Hospital mortality	VATS
		Hospital	After discharge		
COPD	2145	20 (0.9)	5 (0.2)	59 (2.8)	2068
Tumorous disease	124	8 (6.5)	2 (1.6)	15 (12.1)	114
Catamenial	166	0	0	0	166
LAM	38	0	0	0	38
Others (excluding pneumothorax by trauma)	559	12 (2.1)	2 (0.4)	24 (4.3)	520
Unknown	0	0	0	0	0

Operative procedure	Cases	30 Day mortality		Hospital mortality	VATS
		Hospital	After discharge		
Bullectomy	433	4 (0.9)	1 (0.2)	8 (1.8)	417
Bullectomy with additional procedure	1828	17 (0.9)	4 (0.2)	42 (2.3)	1779
Coverage with artificial material	1736	16 (0.9)	4 (0.2)	38 (2.2)	1689
Parietal pleurectomy	6	0	0	0	5
Coverage and parietal pleurectomy	23	0	0	2 (8.7)	23
Others	63	1 (1.6)	0	2 (3.2)	62
Others	768	19 (2.5)	4 (0.5)	48 (6.3)	707
Unknown	3	0	0	0	3
Total	3032	40 (1.3)	9 (0.3)	98 (3.2)	2906

(), Mortality %

Table 24 F. Chest wall deformity

	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
F. Chest wall deformity	181	0	0	0
Funnel chest	8	0	0	0
Others	7	0	0	0

(), Mortality %

Table 25 G. Diaphragmatic hernia

	Cases	30-Day mortality		Hospital mortality	VATS
		Hospital	After discharge		
G. Diaphragmatic hernia	37	0	0	0	19
Congenital	9	0	0	0	8
Traumatic	13	0	0	0	6
Others	15	0	0	0	5

(), Mortality %

Table 26 H. Chest trauma

	Cases	30-Day mortality		Hospital mortality	VATS
		Hospital	After discharge		
H. Chest trauma	426	26 (6.1)	0	31 (7.3)	277

(), Mortality %

Table 28 Lung transplantation

	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
Single lung transplantation from brain-dead donor	29	0	0	1 (3.4)
Bilateral lung transplantation from brain-dead donor	29	0	0	2 (6.9)
Lung transplantation from living donor	17	1 (5.9)	0	2 (11.8)
Total lung transplantation	75	1 (1.3)	0	5 (6.7)
Donor of living donor lung transplantation	33	0	0	0

(), Mortality %

Table 29 Video-assisted thoracic surgery

	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
Video-assisted thoracic surgery	64,036	191 (0.3)	58 (0.09)	424 (0.7)

(), Mortality %

(including thoracic sympathectomy 160)

Table 27 shows operations for other diseases, including 81 cases of arteriovenous malformation and 113 cases of pulmonary sequestration.

A total of 75 lung transplantations were performed in 2016 (Table 28): 58 patients received lung transplants from brain-dead donors and 17 received transplants from living-

Table 27 I. Other respiratory surgery

	Cases	30-Day mortality		Hospital mortality	VATS
		Hospital	After discharge		
I. Other respiratory surgery	1394	28 (2.0)	1 (0.1)	78 (5.6)	1008
Arteriovenous malformation	81	0	0	1 (1.2)	78
Pulmonary sequestration	113	0	0	0	95
Postoperative bleeding · air leakage	428	15 (3.5)	1 (0.2)	40 (9.3)	292
Chylothorax	67	1 (1.5)	0	2 (3.0)	55
Others	705	12 (1.7)	0	35 (5.0)	488

(), Mortality %

Table 30 Tracheobronchoplasty

	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
Tracheobronchoplasty	790	11 (1.4)	1 (0.1)	26 (3.3)
Trachea	41	1 (2.4)	0	1 (2.4)
Sleeve resection with reconstruction	32	0	0	0
Wedge with simple closure	2	0	0	0
Wedge with patch closure	1	0	0	0
Total laryngectomy with tracheostomy	1	0	0	0
Others	5	1 (20.0)	0	1 (20.0)
Carinal reconstruction	22	1 (4.5)	0	1 (4.5)
Sleeve pneumonectomy	17	1 (5.9)	0	5 (29.4)
Sleeve lobectomy	483	2 (0.4)	1 (0.2)	7 (1.4)
Sleeve segmental excision	17	0	0	0
Bronchoplasty without lung resection	26	1 (3.8)	0	3 (11.5)
Others	184	5 (2.7)	0	9 (4.9)

(), Mortality %

Table 31 Pediatric surgery

	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
Pediatric surgery	353	2 (0.6)	0	3 (0.8)

(), Mortality %

related donors. The number of lung transplantation procedures has increased slightly.

The number of VATS procedures has increased annually, reaching 64,036 (77.9% of all general thoracic surgeries) in 2016 (Table 29).

The details of tracheobronchoplasty, pediatric surgery, and combined resection of neighboring organs are shown in Tables 30, 31, and 32, 33.

Table 32 Combined resection of neighboring organ(s)

	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
Combined resection of neighboring organ(s)	1396	5 (0.4)	6 (0.4)	20 (1.4)
Organ resected	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
A. Primary lung cancer				
Aorta	12	0	0	0
Superior vena cava	29	1 (3.4)	0	2 (6.9)
Brachiocephalic vein	7	0	0	0
Pericardium	102	2 (2.0)	1 (1.0)	3 (2.9)
Pulmonary artery	103	0	0	3 (2.9)
Left atrium	17	0	0	2 (11.8)
Diaphragm	62	1 (1.6)	1 (1.6)	4 (6.5)
Chest wall (including ribs)	347	1 (0.3)	2 (0.6)	4 (1.2)
Vertebra	16	0	0	1 (6.3)
Esophagus	4	0	0	0
Total	699	5 (0.7)	4 (0.6)	19 (2.7)
B. Mediastinal tumor				
Aorta	6	0	0	0
Superior vena cava	68	0	0	0
Brachiocephalic vein	122	1 (0.8)	1 (0.8)	1 (0.8)
Pericardium	358	1 (0.3)	1 (0.3)	2 (0.6)
Pulmonary artery	5	0	0	0
Left atrium	0	0	0	0
Diaphragm	47	0	1 (2.1)	0
Chest wall (including ribs)	8	0	0	0
Vertebra	4	0	0	0
Esophagus	8	0	0	0
Lung	524	1 (0.2)	2 (0.4)	2 (0.4)
Total	1150	3 (0.3)	5 (0.4)	5 (0.4)

(), Mortality %

Table 33 Operation of lung cancer invading the chest wall of the apex

	Cases	30-Day mortality		Hospital mortality
		Hospital	After discharge	
Operation of lung cancer invading the chest wall of the apex	754	3 (0.4)	2 (0.3)	7 (0.9)

(), Mortality %

Includes tumors invading the anterior apical chest wall and posterior apical chest wall (superior sulcus tumor, so called Pancoast type)

(C) Esophageal surgery

During 2016 alone, a total of 12,753 patients with esophageal diseases were registered from 543 institutions (response rate: 93.0%) affiliated to the Japanese Association for Thoracic Surgery and/or to the Japan Esophageal Society. Among these institutions, those where 20 or more patients underwent esophageal surgeries within 2016 were 133 institutions (24.5%), which shows no definite shift of esophageal operations to high-volume institutions when compared to the data of 2015 (23.8%) (Table 34). Of 2418 patients with a benign esophageal disease, 1525 (63.1%) patients underwent surgery, and 73 (3.0%) patients underwent endoscopic resection, while 820 (33.9%) patients did not undergo any surgical treatment (Table 35). Of 10,830 patients with a malignant esophageal tumor, 8296 (76.6%) patients underwent resection, with esophagectomy for 6158 (56.9%) and endoscopic mucosal resection (EMR) or endoscopic submucosal dissection (ESD) for 2138 (19.7%), while 2534 (23.4%) patients did not undergo any resection (Tables 36, 37). The annual trend of registered in-patients with esophageal diseases has not changed in the last decades (Fig. 3).

Table 34 Distribution of number of esophageal operations in 2016 in each institution

Esophageal surgery			
Number of operations in 2016	Benign esophageal diseases	Malignant esophageal disease	Benign + malignant
0	241	107	70
1-4	244	138	138
5–9	42	98	107
10–19	9	85	95
20–29	2	34	41
30–39	3	28	26
40–49	1	16	22
≥ 50	1	37	44
Total	543	543	543

Among benign esophageal diseases (Table 35), hiatal hernia, achalasia, esophageal varices, and esophagitis (including reflux esophagitis) were the most common conditions in Japan. On the other hand, benign esophageal tumors, spontaneous rupture of the esophagus, and congenital esophageal atresia were common diseases that were surgically treated, as well as the above-mentioned diseases. Open surgery was performed in 1030 (67.5%) patients with a benign esophageal disease, with 30-day mortality in 6 (0.6%), while thoracoscopic and/or laparoscopic surgery was performed for 495 (32.5%) patients, with no 30-day mortality. The difference in these death rates between open and endoscopic surgery seems to be related the conditions requiring open surgery.

The majority of malignant diseases were carcinomas (Table 36). Among esophageal carcinomas, the incidence of squamous cell carcinoma was 89.6%, while that of adenocarcinomas including Barrett's cancer was 7.8%. The resection rate for patients with a squamous cell carcinoma was 75.3%, while that for patients with an adenocarcinoma was 89.7%.

According to location, cancer in the thoracic esophagus was the most common (Table 37). Of the 4305 patients (40.0% of all esophageal malignancies) having superficial esophageal cancers within mucosal and submucosal layers, 6158 (56.9%) patients underwent esophagectomy, while 2138 (19.7%) patients underwent EMR or ESD. The 30-day mortality rate and hospital mortality rate after esophagectomy for patients with a superficial cancer were 0.4% and 0.8%, respectively.

Multiple primary cancers were observed in 2068 (19.1%) of the 10,830 patients with esophageal cancer. Synchronous cancer was found in 1008 (9.3%) patients, while metachronous cancer was observed in 1060 (9.8%) patients. The stomach, and head and neck region are the common sites for both synchronous and metachronous malignancies (Table 37).

Among esophagectomy procedures, transthoracic esophagectomy through right thoracotomy was the most commonly performed for patients with a superficial cancer, as well as for those with an advanced cancer (Table 38). Transhiatal esophagectomy, commonly performed in western countries, was performed in only 5.8% of patients

Table 35 Benign esophageal diseases

	Operation(+)										Endoscopic resection	Operation (–)	Total
	Number of patients			Hospital mortality			T/L*3			Total			
	Total	Open	T/L*3	Open surgery			≤ 30 days	31–90 days	Total (including after 91 days mortality)				
				≤ 30 days	31–90 days	Total (including after 91 days mortality)							
1. Achalasia	211	119	92	0	0	0	0	0	0	0		36	247
2. Benign tumor	133	80	53	0	0	0	0	0	0	0	51	60	244
(1) Leiomyoma	77	47	30	0	0	0	0	0	0	0	25	12	114
(2) Cyst	18	9	9	0	0	0	0	0	0	0	0	0	18
(3) Others	38	24	14	0	0	0	0	0	0	0	26	48	112
(4) Not specified	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Diverticulum	34	24	10	0	0	0	0	0	0	0		6	40
4. Hiatal hernia	680	395	285	2 (0.5)	1 (0.3)	4 (1.0)	0	1 (0.4)	2 (0.7)	6 (0.9)		136	816
5. Spontaneous rupture of the esophagus	104	92	12	1 (1.1)	4 (4.3)	6 (6.5)	0	0	0	6 (5.8)		8	112
6. Esophago-tracheal fistula	25	22	3	1 (4.5)	1 (4.5)	2 (9.1)	0	0	0	2 (8.0)		11	36
7. Congenital esophageal atresia	52	46	6	0	0	0	0	0	0	0		4	56
8. Congenital esophageal stenosis	7	6	1	0	0	0	0	0	0	0		5	12
9. Corrosive stricture of the esophagus	12	7	5	0	1 (14.3)	1 (14.3)	0	0	0	1 (8.3)		2	14
10. Esophagitis, Esophageal ulcer	57	44	13	0	0	0	0	0	0	0			57
11. Esophageal varices	123	121	2	1 (0.8)	0	1 (0.8)	0	0	0	1 (0.8)		531	654
(1) Laparotomy	28	26	2	0	0	0	0	0	0	0			28
(2) Sclerotherapy												168	168
(3) EVL												303	303
12. Others	87	74	13	1 (1.4)	3 (4.1)	6 (8.1)	0	0	0	6 (6.9)	22	21	130
Total	1525	1030	495	6 (0.6)	10 (1.0)	20 (1.9)	0	1 (0.2)	2 (0.4)	22 (1.4)	73	820	2418

(), Mortality %

T/L thoracoscopic and/or laparoscopic

Table 36 Malignant esophageal diseases (histologic classification)

		Resection (+)	Resection (−)	Total
Carcinomas		8240	2534	10,774
1	Squamous cell carcinoma	7273	2381	9654
2	Basaloid(-squamous)carcinoma	65	8	73
3	Carcinosarcoma	35	2	37
4	Adenocarcinoma in the Barrett's esophagus	414	36	450
5	Other adenocarcinoma	343	51	394
6	Adenosquamous carcinoma	26	5	31
7	Mucoepidermoid carcinoma	4	1	5
8	Adenoid cystic carcinoma	0	0	0
9.	Endocrine cell carcinoma	53	25	78
10	Undifferentiated carcinoma	8	6	14
11	Others	19	19	38
Other malignancies		43	6	49
1	Malignant non-epithelial tumors	16	0	16
2	Malignant melanoma	23	6	29
3	Other malignant tumors	4	0	4
Not specified		56	0	56
Total		8339	2540	10,879

Resection: including endoscopic resection

having a superficial cancer and advanced cancer who underwent esophagectomy in Japan. Thoracoscopic and/or laparoscopic esophagectomy was performed for 1296 patients (67.7%) with a superficial cancer and for 2060 patients (48.6%) with an advanced cancer. The number of cases of thoracoscopic and/or laparoscopic surgery for superficial or advanced cancer has been increasing for several years (Fig. 4).

Combined resection of the neighboring organs during resection of an esophageal cancer was performed in 226 patients (Tables 38, 39). Resection of the aorta together with esophagectomy was performed in 3 cases. Tracheal and/or bronchial resection combined with esophagectomy was performed in 12 patients, with both 30-day mortality and hospital mortality of 0%. Lung resection combined with esophagectomy was performed in 56 patients, with 30-day mortality of 0% and hospital mortality of 3.6%.

Salvage surgery after definitive (chemo-) radiotherapy was performed in 250 patients, with 30-day mortality of 1.6% and hospital mortality of 6.0% (Table 38).

Lastly, we should continue our efforts for complete surveys through more active collaboration with the Japan Esophageal Society and other related societies.

Table 37 Malignant esophageal diseases (clinical characteristics)

	Operation (+)				EMR or ESD	Operation (−)	Total
	Cases	Hospital mortality					
		≤ 30 days	31–90 days	Total (including after 91 days mortality)			
1. Esophageal cancer	6158	40 (0.6)	41 (0.7)	101 (1.6)	2138	2534	10,830
Location							
(1) Cervical esophagus	251	1 (0.4)	5 (2.0)	9 (3.6)	100	214	565
(2) Thoracic esophagus	4958	31 (0.6)	33 (0.7)	81 (1.6)	1711	2067	8736
(3) Abdominal esophagus	697	7 (1.0)	1 (0.1)	8 (1.1)	126	125	948
(4) Multiple cancers	251	1 (0.4)	1 (0.4)	2 (0.8)	186	56	493
(5) Others/not described	1	0	1 (100.0)	1	15	72	88
Tumor depth							
(A) Superficial cancer(T1)	1913	8 (0.4)	5 (0.3)	15 (0.8)	2124	268	4305
Mucosal cancer (*T1a*)	361	0	0	0	1857	47	2265
(B) Advanced cancer (T2–T4)	4240	32 (0.8)	36 (0.8)	86 (2.0)	11	2264	6515
(C) Not specified	5	0	0	0	3	2	10
2. Multiple primary cancers	1076	5 (0.5)	11 (1.0)	23 (2.1)	556	436	2068
1) Synchronous	589	1 (0.2)	7 (1.2)	14 (2.4)	210	209	1008
(1) Head and neck	197	0	4 (2.0)	4 (2.0)	82	65	344
(2) Stomach	199	1 (0.5)	1 (0.5)	3 (1.5)	62	57	318
(3) Colorectum	64	0	1 (1.6)	4 (6.3)	20	22	106
(4) Lung	47	0	0	1 (2.1)	13	13	73
(5) Pancreas	4	0	0	0	0	2	6
(6) Liver	5	0	0	1 (20.0)	3	8	16
(7) Others	35	0	0	0	11	24	70
(8) Triple cancers	38	0	1 (2.6)	1 (2.6)	18	18	74
(9) Unknown	0	0	0	0	1	0	1
2) Metachronous	487	4 (0.8)	4 (0.8)	9 (1.8)	346	227	1060
(1) Head and neck	104	1 (1.0)	0	1 (1.0)	130	36	270
(2) Stomach	104	2 (1.9)	3 (2.9)	5 (4.8)	83	53	240
(3) Colorectum	71	1 (1.4)	0	1 (1.4)	24	26	121
(4) Lung	32	0	0	0	13	23	68
(5) Pancreas	0	0	0	0	0	3	3
(6) Liver	3	0	0	0	3	7	13
(7) Others	136	0	1 (0.7)	1 (0.7)	49	52	237
(8) Triple cancers	37	0	0	1 (2.7)	41	27	105
(9) Unknown	0	0	0	0	3	0	3
Unknown	0	0	0	0	0	0	0

Table 38 Malignant Esophageal diseases (surgical procedures)

	Operation (+)				Thoracoscopic and/or laparoscopic procedure				EMR or ESD
	Cases	Hospital mortality			Cases	Hospital mortality			
		≤ 30 days	31–90 days	Total (including after 91 days mortality)		≤ 30 days	31–90 days	Total (including after 91 days mortality)	
Superficial cancer (T1)	1913	8 (0.4)	5 (0.3)	15 (0.8)	1296	3 (0.2)	4 (0.3)	8 (0.6)	2124
Mucosal cancer (T1a)	361	0	0	0	224	0	0	0	1857
Esophagectomy	1913	8 (0.4)	5 (0.3)	15 (0.8)	1296	3 (0.2)	4 (0.3)	8 (0.6)	2124
(1) Transhiatal esophagectomy	110	3 (2.7)	0	3 (2.7)	14	0	0	0	
(2) Transthoracic (rt.) esophagectomy and reconstruction	1645	5 (0.3)	4 (0.2)	11 (0.7)	1229	3 (0.2)	4 (0.3)	8 (0.7)	
(3) Transthoracic (lt.) esophagectomy and reconstruction	24	0	1 (4.2)	1 (4.2)	0	0	0	0	
(4) Cervical esophageal resection and reconstruction	47	0	0	0	31	0	0	0	
(5) Others	15	0	0	0	5	0	0	0	
(6) Esophagectomy without reconstruction	59	0	0	0	17	0	0	0	
(7) not specified	13	0	0	0	0	0	0	0	
Advanced cancer (T2–T4)									
Esophagectomy	4240	32 (0.8)	36 (0.8)	86 (2.0)	2060	15 (0.7)	19 (0.9)	38 (1.8)	11
(1) Transhiatal esophagectomy	244	3 (1.2)	2 (0.8)	5 (2.0)	33	1 (3.0)	0	1 (3.0)	
(2) Transthoracic (rt.) esophagectomy and reconstruction	3638	26 (0.7)	30 (0.8)	68 (1.9)	1986	13 (0.7)	18 (0.9)	35 (1.8)	
(3) Transthoracic (lt.) esophagectomy and reconstruction	110	1 (0.9)	0	1 (0.9)	3	0	0	0	
(4) Cervical esophageal resection and reconstruction	133	0	0	2 (1.5)	11	0	0	0	
(5) Others	38	1 (2.6)	1 (2.6)	3 (7.9)	7	0	0	0	
(6) Esophagectomy without reconstruction	77	1 (1.3)	2 (2.6)	6 (7.8)	20	1 (5.0)	1 (5.0)	2 (10.0)	
(7) not specified	0	0	1	1	0	0	0	0	
(Depth not specified)	5	0	0	0	0	0	0	0	0
Combined resection of other organs	226	1 (0.4)	4 (1.8)	8 (3.5)					
(1) Aorta	3	0	0	0					
(2) Trachea, Bronchus	12	0	0	1 (8.3)					
(3) Lung	56	0	2 (3.6)	2 (3.6)					
(4) Others	155	1 (0.6)	2 (1.3)	5 (3.2)					
Unknown	0	0	0	0					
Salvage surgery	250	4 (1.6)	8 (3.2)	15 (6.0)	69	2 (2.9)	3 (4.3)	5 (7.2)	26

Table 39 Mortality after combined resection of the neighbouring organs

Year	Esophagectomy			Combined resection											
	a	b	c (%)	Aorta			Tracheobronchus			Lung			Others		
				a	b	c (%)	a	b	c (%)	a	b	c (%)	a	b	c (%)
1996	4194	120	2.86	7	3	42.86	24	0	0.00	50	2	4.00	78	4	5.13
1997	4441	127	2.86	1	0	0.00	34	5	14.71	56	1	1.79	94	3	3.19
1998	4878	136	2.79	4	0	0.00	29	0	0.00	74	1	1.35	128	2	1.56
1999	5015	116	2.31	5	0	0.00	23	2	8.70	68	0	0.00	122	1	0.82
2000	5350	81	1.51	2	0	0.00	23	2	8.70	69	0	0.00	96	1	1.04
2001	5521	110	1.99	1	0	0.00	26	1	3.85	83	3	3.61	99	2	2.02
2002	4904	66	1.35	3	1	33.33	20	2	10.00	63	0	0.00	63	1	1.59
2003	4639	45	0.97	0	0	0.00	24	2	8.33	58	0	0.00	88	1	1.14
2004	4739	64	1.35	2	0	0.00	17	0	0.00	59	5	8.47	119	2	1.68
2005	5163	52	1.01	1	0	0.00	11	1	9.09	67	1	1.49	73	1	1.37
2006	5236	63	1.20	0	0	0.00	17	0	0.00	62	2	3.23	122	3	2.46
2007	4990	60	1.20	0	0	0.00	25	1	4.00	44	1	2.27	138	2	1.45
2008	5124	63	1.23	0	0	0.00	17	1	5.88	48	1	2.08	185	0	0.00
2009	5260	63	1.20	0	0	0.00	19	2	10.53	58	2	3.45	211	3	1.42
2010	5180	45	0.87	2	0	0.00	33	0	0.00	58	0	0.00	245	5	2.04
2011	5430	38	0.70	4	0	0.00	26	0	0.00	41	0	0.00	179	5	2.79
2012	6055	47	0.78	2	0	0.00	23	1	4.35	69	0	0.00	240	1	0.42
2013	5824	41	0.70	2	0	0.00	44	0	0.00	77	1	1.30	156	3	1.92
2014	6244	47	0.75	2	0	0.00	24	0	0.00	77	3	3.90	227	3	1.32
2015	6151	39	0.63	3	0	0.00	15	0	0.00	67	3	4.48	266	4	1.50
2016	6158	40	0.65	3	0	0.00	12	0	0.00	56	0	0.00	155	1	0.65
Total	1,10,496	1463	1.32	44	4	9.09	486	20	4.12	1304	26	1.99	3084	48	1.56

[a]Number of patients who underwent the operation

[b]Number of patients who died within 30 days after operation

[c]% ratio of b/a, i.e., direct operative mortality

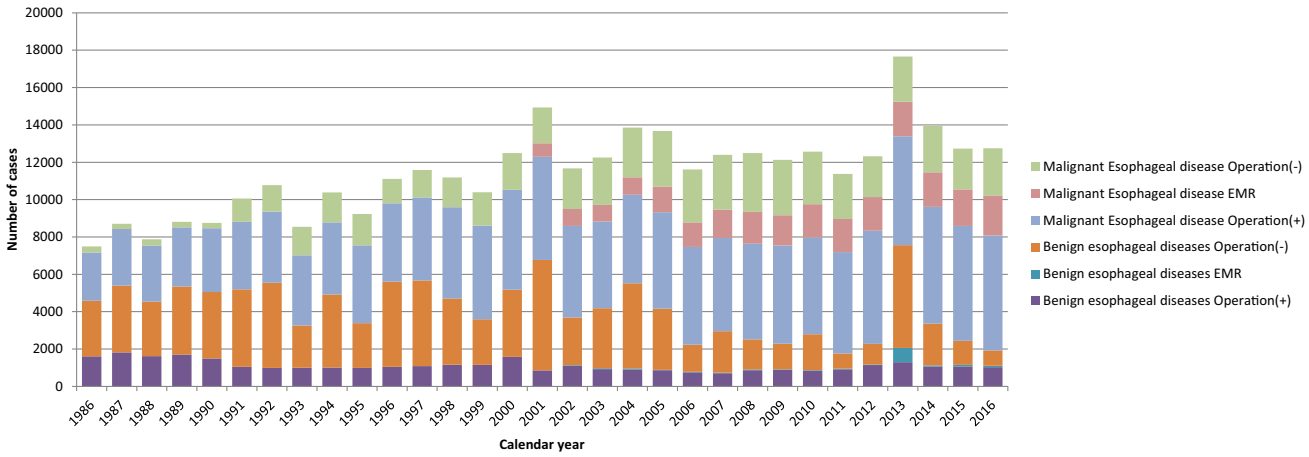

Fig. 3 Annual trend of in-patients with esophageal diseases. *EMR* endoscopic mucosal resection (including endoscopic submucosal)

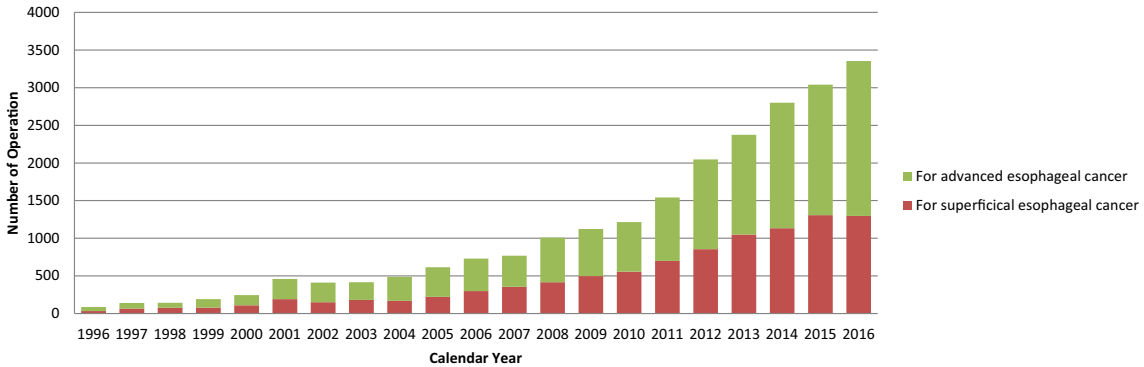

Fig. 4 Annual trend of video-assisted esophagectomy for esophageal malignancy

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